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OF THE

FRANKLIN INSTITUTE,

DEVOTED TO

SCIENCE AND THE MECHANIC ARTS.

EDITED BY

Chas. Bullock, Prof. Persifor Frazer, D.Sc., Prof. Edwin J. Houston, Theo. D. Rand, Prof. Coleman Sellers, Committee on Publication:
with the Assistance of
Dr. Wm. H. Wahl, Secretary of the Institute.

COLLABORATORS:

Prof. L. D'Auria, Prof. Wm. H. Greene, Prof. Lewis M. Haupt, Prof. Chas. F. Himes,
Carl Hering. Dr. S. C. Hooker, Prof. Geo. A. Koenig, Otto Lüthy,
Prof. Wm. D. Marks, Prof. S. C Sadtler, H. W. Spangler, U.S.N., Prof. Henry Trimble.

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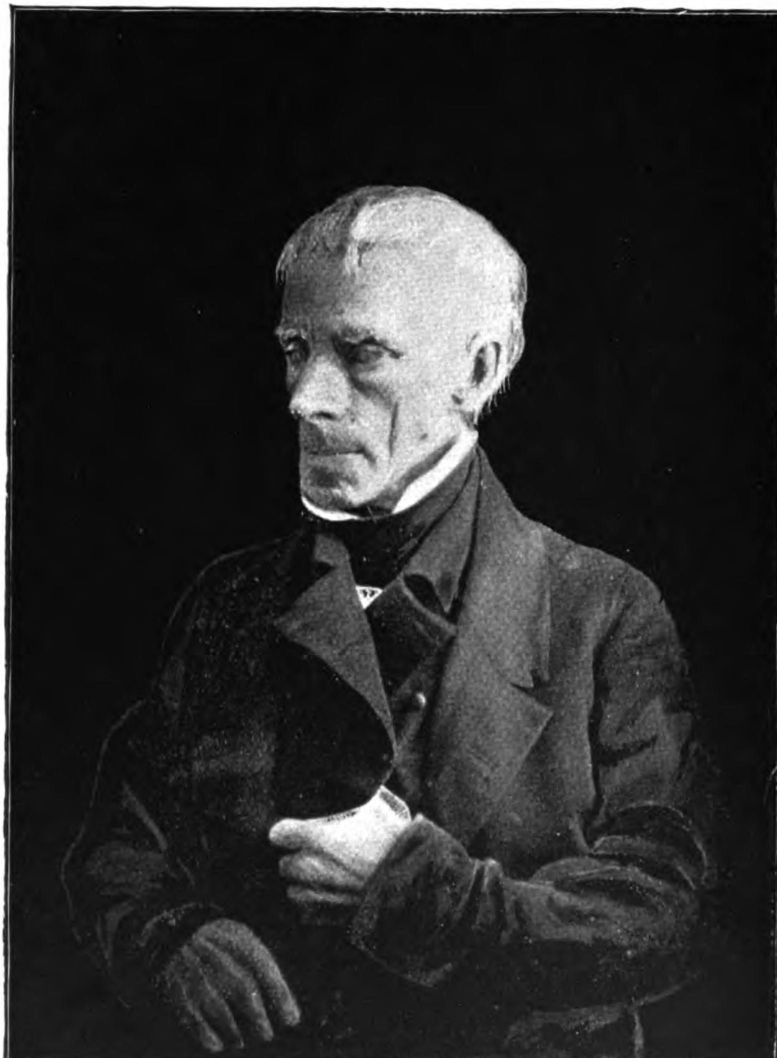


DR. THOMAS P. JONES,
Founder of the JOURNAL, and Editor from 1826 to 1848.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXX. JULY, 1890. No. 1

THE FRANKLIN INSTITUTE is not responsible for the statements and opinions advanced by contributors to the JOURNAL.

MEMOIR OF DR. THOMAS P. JONES.

By FRANCIS FOWLER.

[Dr. JONES was so closely identified with the origin and early history of the JOURNAL, that the Committee on Publication feels that no further explanation than this statement will be needed in presenting in its pages the excellent memoir prepared for the United States Patent Office by Prof. Fowler. The Committee feels that in making this publication, it is doing only tardy and incomplete justice to the memory of one, to whom the JOURNAL is indebted more than to any other, for the zeal and rare ability with which, as editor, he directed the JOURNAL during the first twenty-two years of its existence. The fact that his colleagues elected him editor for life is the best evidence of the value which they placed upon his services.

The Committee has been able, also, to supplement Prof. Fowler's sketch, with an excellent likeness of the subject of this memoir.—*The Committee on Publications.*]

Dr. THOMAS P. JONES was born in Herefordshire County, England, in the year 1774, and, soon after coming to this country, settled in Newborn, N. C.

In December, 1825, he was appointed Professor of Mechanics and Natural Philosophy in the FRANKLIN INSTITUTE of Philadelphia, which was organized in February, 1824, and he entered upon his duties January 4, 1826. At the same time he was placed in charge of the FRANKLIN JOURNAL as its first editor, the first number having been issued early in that year.

At the annual meeting of the INSTITUTE, January 19, 1826, it was "*Resolved,* That the members view with pleasure the prospect of the FRANKLIN JOURNAL being issued by so able an editor as the Professor of Mechanics in the INSTITUTE, and we recommend it to the support of their fellow-citizens."

In the same report it was stated that "Dr. JONES had consented to undertake the publication of the JOURNAL on his own account, with the assistance of the members and under the patronage of the INSTITUTE."

The address of the editor in taking charge of the JOURNAL is an excellent paper, from which the following extract is taken: "Gentlemen who furnish communications for the FRANKLIN JOURNAL are requested to keep in view that its main object is to diffuse information among artisans and manufacturers; and that it is therefore necessary to write in a style as familiar, and as little technical, as the nature of the subject will admit.

"He earnestly solicits the aid of intelligent mechanics and manufacturers, and assures them that although they may not always be as ready with the pen as with the implements of their respective trades their offerings will be acceptable, and that the labor of revision, when requisite, will be cheerfully performed.

"The age of secrets in arts and trades has nearly passed away. In these pursuits, as well as in that of commerce, liberal views are generally entertained, and a free and open intercourse is acknowledged to be the best policy. The JOURNAL will be a ready vehicle for inquiries and replies upon all subjects within its purview, and will enable the artisan and others to obtain information which might otherwise be sought in vain."

In addition to his other duties, Dr. JONES for several years acted as Recording Secretary of the INSTITUTE and Curator of its Collections.

The original Act establishing the Patent Office was passed in April, 1790, its object as therein stated being "to promote the progress of the useful arts."

The first Superintendent was Dr. William Thornton, a personal friend of Washington, and one of the three Commissioners appointed, in 1794, to lay out the Federal Capital. To the position of Superintendent of the Patent Office, Thornton was appointed in 1802, and held it until his decease, March 28, 1828.

Dr. JONES was appointed his successor April 12, 1828, and he at once removed to Washington. In the preface to Volume 5 of the FRANKLIN JOURNAL, Dr. JONES thus refers to the change:

"It has already become known to the patrons of the JOURNAL that the direction of the National Patent Office has been committed to the editor.

"His induction into this station has been such as to afford him unalloyed pleasure, as his appointment has been made without the slightest reference to political considerations.

"Whilst the station will enlarge the sphere of his usefulness by putting into frequent requisition that information upon the practical application of mechanical and chemical science which it has been the labor of his life to obtain, it will also enable him, through the medium of the JOURNAL, to lay open those stores of the genius and skill of our countrymen, which, although existing in the Patent Office, have hitherto been but partially known."

At the meeting of the INSTITUTE held the same month, April, 1828, the managers express their appreciation of Dr. JONES' services "in a resolution to appoint him editor of the JOURNAL during his life," and in the following annual report is found this record: "The abilities of the gentleman who edits the JOURNAL are known to you all, and we regret that the INSTITUTE has been deprived of his services as the Professor of Mechanics, so well known and respected by all for his urbanity and gentlemanly deportment, whose zeal for the cause of mechanics was only surpassed by his knowledge, from which the INSTITUTE draws so abundantly. The editor's office and station give him an opportunity of noticing all patents as they are issued, and this is done without filling the work with useless and technical verbiage, but by an abstract of the specification, accompanied by the editor's remarks, supplied from a fund of information rarely surpassed."

In the annual report of 1830, this important feature of the JOURNAL is referred to as follows:

"The interest taken in the JOURNAL has been greatly increased by the analysis of patents, which has occupied a large portion during the past year. To those whose attention is called to the construction of new machinery, the knowledge of what has been done by others is of incalculable value, and a work giving a description of all new inventions must be most acceptable."

At this time the personnel of the Patent Office consisted of—

Dr. Thomas P. Jones, Superintendent, salary, $1,500.

William Elliott, Clerk, salary, $1,000.

Alex. McIntire, Clerk, salary, $800.

R. W. Fenwick, Messenger, salary, $400.

Dr. JONES received the appointment of Superintendent of the Patent Office under Henry Clay, Secretary of State, the Patent Office being at that time a Bureau of the State Department, but among the changes made in the first year of Jackson's administration, 1829, was his transfer to the Bureau of Archives, Laws and Commissions in the same department.

This position Dr. JONES held until soon after the organization of the Patent Office, under the Act of July 4, 1836. Hon. H. L. Ellsworth was made Commissioner, on that date, at a salary of $3,000, and Charles M. Keller and Dr. JONES were appointed Examiners, January 4, 1837, at a salary of $1.500 each.

At this time, Dr. JONES was about sixty-four years of age and he remained in the Patent Office only two years longer, resigning his position on the 22d of December, 1838. He continued to reside in Washington during the remainder of his life and devoted himself with unabated zeal to his duties as editor of the JOURNAL. In the annual report of the INSTITUTE frequent references are made to his services, especially in enlarging that part of the JOURNAL devoted to the record of American and foreign patents, to most of which were appended "remarks," showing the remarkable extent, versatility and thoroughness of his knowledge and experience, as well as the unremitted labor and research which the duties involved.

These "remarks," modestly so-called, often embodied scientific matter and treatment of the highest order, as well as criticisms, suggestions and information of great value to inventors and all interested in the practical development of the arts. A collection of these "remarks" would form by themselves a most interesting volume.

It may be truly said that Dr. JONES was at home in almost every branch of mechanics, natural philosophy, chemistry and physics, and was also familiar to a remarkable degree with all the leading practical arts.

The versatility of his talent and acquirements is seen in every issue of the FRANKLIN JOURNAL. For example, in one volume is found an elaborate article on the "Effects of Trades on Health and Morals;" another, on the "Acts of Congress Relating to Patents;" a discussion of court decisions; notices of scientific works; besides detailed descriptions and analyses of *hundreds* of machines patented at home and abroad, from a rotary engine, a machine for sawing marble, a house-heating apparatus, to an automatic chess player.

Also, in the earliest numbers of the JOURNAL are seen the fruits of his extensive acquaintance with the scientific authorities and publications of England and the Continent, including even those of Italy, from which he selected articles and information, which aided so essentially in giving the FRANKLIN JOURNAL the first place among the scientific publications of the country at that time.

Prof. A. D. Bache, of the University of Pennsylvania, in his address before the INSTITUTE, in 1842, sets forth the great value imparted to the JOURNAL by "the copious extracts from foreign journals conveying the improvements of Europe to our own mechanics, a feature commenced and conducted by Dr. JONES."

As showing the interest Dr. JONES took in the improvement of the working classes, the following incident appears in the minutes of a meeting of the Board:

"Application has been made by the Philadelphia Sunday-school Union for the use of the Institute Hall on the Sabbath Day, for the moral and religious instruction of apprentices; and, as this object is in unison with those of the INSTITUTE, it has been determined to let it for that purpose."

When no longer connected with the Patent Office, his interest in the progress and in the development of inventive talent in this country, as well as in the general improvement of the artisan classes continued to the last years of his life.

As editor, he was always ready to recognize and warmly encourage genuine invention; but he was equally watchful and uncompromising in showing the defects he believed to exist in any patented invention, especially in those cases in which the invention embodied no possible advantage or gain to the public, and was, therefore, worse than useless, as the official stamp of patentability might be used to impose on the credulity and ignorance of many.

In the early numbers of the JOURNAL, he published a few articles, entitled "Modern Antiques," the purpose of which, as he says, "is to show the disposition of our remote ancestors to deprive us of the honor of being the true and origi-

nal inventors, and who peep from their graves to dispute the rights of those who have issued to the world their new-born projects."

Dr. JONES died in Washington, March 11, 1848, and was buried in the Congressional Cemetery. He had two daughters, one of whom married Mr. Alger, of Boston.

The FRANKLIN INSTITUTE, in connection with the formal announcement of his death, passed the following resolutions:

"*Resolved*, That the members of the FRANKLIN INSTITUTE have heard with the most profound sorrow that Dr. THOMAS P. JONES, one of the earliest of their associates, departed this life on the 11th day of March last, after a long career of usefulness in the walks of mechanical science.

"*Resolved*, That the services of Dr. JONES as the founder and able editor of the JOURNAL OF THE INSTITUTE, from the time the publication of it was commenced until his death, and also for several years as the Professor of Natural Philosophy and Mechanics in the Institution, will ever be gratefully remembered by all who have participated in the labors and advantages of our Society.

"*Resolved*, That we sincerely condole with the family of Dr. JONES in their recent and irreparable bereavement, and that a copy of these resolutions be transmitted to them by the Corresponding Secretary."

WHAT DOES A STEAM HORSE-POWER COST?

BY THOS. PRAY, JR., M.E., C.E., Boston.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *December 20, 1889.*]

[*Concluded from vol. cxxix, page 489.*]

WHAT DOES A STEAM HORSE-POWER COST?—NO. 2.

Joule's equivalent = 772· units of work, or heat required to raise one pound of water 1° F., or one pound one foot high.

Unit of evaporation equals 966·1 British thermal units.

$\frac{33{,}000 \text{ pounds}}{772 \text{ Joule's}} = 42{\cdot}746$ of heat units to make one horse-power one minute, and $42{\cdot}746 \times 60 = 2565{\cdot}76$ heat units per hour for one horse-power required.

Then $\frac{2565{\cdot}76}{966{\cdot}1} = 2{\cdot}6558$ pounds of water required, if *no loss*, to make one horse-power per hour.

Good anthracite coal has 14,500 heat units per pound, then $\frac{14{,}500 \text{ heat units}}{966{\cdot}1 \text{ heat units}} = 15{\cdot}082$ pounds of water should be evaporated with one pound of coal, if no loss.

Then $\frac{2{\cdot}6558}{15{\cdot}083} = {\cdot}018148$ pounds coal per horse-power per hour, if no loss, or 5·510 horse-powers one hour with one pound of coal.

Boilers do evaporate ten and one-half to twelve pounds water, with one pound of coal, in regular commercial duty and in 5,000 horse-power plants.

In Table No. 2, we have the heat units and the basis of all computations into which "heat units" enter, and the study of this branch of the question may be considered one of the most bewitching of all, and one that is so little under-

stood. Heat, heat units, sensible heat, latent heat, specific heat, all enter into coal, water, steam and all substances known to man. •Heat from the combustion of coal, acting through the boiler shell upon water, causes its conversion into steam, and then the steam in turn acts on a moving medium and overcomes resistance or "*does work*" and is gradually returned to its original water with a higher or lower efficiency in conversion of heat into work. The slide (No. 2) shows the possibilities of heat, or what we could do, if only we were not subject to natural laws. Mr. Joule determined, over forty years ago, that 772 units of work were required to raise a pound of water 1° F., and the same number exactly equals raising one pound one foot high.

The unit of evaporation equals 966·1 British thermal units, required to turn one pound of water into steam at atmospheric pressure. As we wish to know what a horse-power should and does cost, we can begin by ascertaining what the possibilities are. We know that 33,000 units of work constitute a horse-power, and that it requires one Joule to develop a unit of work, then $33{,}000 \div 772 = 42{\cdot}746$, the number of heat units to make a horse-power one minute, and 42·746 heat units $\times$ by 60 minutes, give us the number of heat units necessary for a horse-power one hour, or 2565·76, and as we must use water from which to make steam, and we know that it requires 966·1 thermal units to make a pound of water into steam, by dividing 2565·76 by 966·1, we can tell how many pounds of water are required to make a horse-power, if only no loss occur = 2·6558, a quantity very much smaller than we meet with in practice.

We know also that good coal has about 14,500 heat units in a pound, and $14{,}500 \div 966{\cdot}1 = 15{\cdot}082$ pounds of water should be evaporated with one pound of coal, if no loss, and $2{\cdot}6558 \div 15{\cdot}083 = {\cdot}018148$ pounds of coal per horse-power per hour, if no loss, or 5·510 horse-power per pound of coal per hour.

We must now seek the cause for this very wide discrepancy between possible and actual results, for there are more engines that require five pounds of coal per horse-power per

hour, than yield five horse-powers for one pound of coal per hour. We also know that many boilers are running in every-day work that give an evaporation of eight to ten and one-half and even twelve pounds of water with one pound of coal, and this shows only a part of the loss, and we must seek the remainder of "not accounted for" in our next.

WHAT DOES A STEAM HORSE-POWER COST?—NO. 3.

Application of Carnot's Law.

$$\text{Efficiency,} = \frac{\text{Range of temp. above absolute zero.}}{\text{higher limit of absolute temp.}}$$

Initial pressure = 125 lbs. Term. pressure = 10 lbs.
Initial temp. = 361° F. Term. temp. =267° F.

then

$$\frac{361 + 461{\cdot}2 - 267 + 461{\cdot}2}{361{\cdot} + 461{\cdot}2} = \frac{94^\circ}{822{\cdot}2^\circ} = 11{\cdot}432 \text{ p. c. efficiency}$$

Another case:

Initial pressure = 80 lbs. Term. pressure = 54 lbs.
Initial temp. = 334° F. Term. temp. = 314° F.

then

$$\frac{334 + 461{\cdot}2 - 314 + 461{\cdot}2}{334{\cdot} + 461{\cdot}2} = \frac{20{\cdot}}{795{\cdot}2} = 02{\cdot}515 \text{ per cent. effi-}$$

ciency, or one engine does nearly five time as efficient work in heat units as the other.

Losses.

Imperfect combustion.
Convection of heat to the water.
Leakages of joints, valves, etc.
External condensation.
Frictional condensation in pipes and ports.
Small steam room of boiler.
Excessive clearance in cylinder and ports.
Surface condensation of piston and cylinder walls.
Loss by exhaust into open air or condenser.

We see here Carnot's law, previously referred to, in which the higher minus the lower absolute temperature ÷ by the higher limit of absolute temperature gives us the efficiency in the engine as a heat machine or converter of heat into work. Two instances are given, the one with initial pressure of 125 pounds, terminal of ten pounds, showing a range of 94° F. only, as giving 11·432 per cent. of efficiency, in contrast with which is given an example of a throttling engine with an initial of eighty pounds and terminal of fifty-four pounds, or a range of only 20° F. and an efficiency of only 2·5 per cent., showing one engine as a converter of heat into power with nearly five times the efficiency of the other—in a condensing and non-condensing engine doing the same work, with same boiler and same steam pressure, in one case 156° is the range—the other 82·5°, or almost double the efficiency—while in the condensing engine less steam in volume would be used to effect the overcoming of the same resistance, a fact steam-users frequently fail entirely to comprehend; and in all comparisons, *absolute* pressures and temperatures must be used—not *relative* or *apparent*. And another fact frequently lost sight of is that the ratio of gain *in cost* is greater as higher initial pressures are used up to about 120 pounds; and a noteworthy fact is that Mr. Corliss, for some years prior to his death, used 125 pounds gauge-pressure or 140—absolute as the point of best results—where lubrication could be steadily maintained, at minimum cost. The advantages of expansion in his simple compound, like the Pawtucket and Providence pumping engines, with not the most efficient boiler, cause them to show a horse-power with 13·7 pounds of water per hour, an amount seldom approached by even the most recent triple expansion compounds—stationary or marine—and his engines are not up to 300 I.H.P., as compared with 1,000 to 5,000 I.H.P., of the modern types referred to, in which cases, all of most modern appliances for making steam have been fully adopted.

LOSSES.

The items in No. 3 would require an evening to discuss in any way worthy their importance. Rankine has treated

of each in his *Steam Engine* so fully that it is better to refer you who desire to understand the subject, direct to the best authority extant. The form and adaptation of boilers are a study, and the results vary in almost all particulars, when conditions are regarded. ·6 is low and ·75 high accomplished results in every-day practice at the boiler. Leakage and condensation reduce this as more or less care is exercised over pipes and passages. External condensation, caused by lack of covering of pipes, etc., is a material factor of loss. Internal condensation by small pipes, obstacles, as valves, elbows, short turns and various obstructions, frequently cause a loss of twenty-five per cent. in economy and make a large amount of water present.

Small steam-room means water in the steam, and the clearance of engines in cylinder and ports becomes frequently as high as sixteen to eighteen per cent. by the use of single valves and various other ancient adaptations of a so-called economical order. Cylinder condensation causes large losses in heat, running up to thirty or forty per cent. of the realized initial temperature and pressure, while other matters of more or less import enter in and call for necessary factors for comparison.

WHAT DOES A STEAM HORSE-POWER COST?—NO. 4.

Necessary Factors for Comparison.

Coal per one I.H.P. per hour.
Cost of coal per ton.
Pounds of water per one I.H.P. actual.
Evaporation per pound of coal.
Initial steam-pressure, absolute.
Terminal steam-pressure, absolute.
I.H.P.
Calorimetric conditions at engine, and boiler.

Conclusions Necessary.

Cost of one I.H.P. one hour for coal, in mills.
Cost of one I.H.P. twenty-four hours for coal, in cents.
Cost of total load per hour for coal.
Pounds of coal per hour and twenty-four hours, in cents.

Pounds of water per hour and twenty-four hours.

All the above give the only correct comparisons between one and another steam plant as to dollars and cents.

Pounds of coal, without cost of coal per ton, means nothing so far as the cost of a horse-power per hour, day or year goes, and the relative cost of a horse-power in dollars and cents in different localities amounts to nothing beyond an assertion, unless we know the actual number of pounds of water evaporated by a pound of coal, and then we must know for comparison or for fact the amount of water carried over in the steam, for the boiler gets credit for an evaporation that is entirely fictitious, in case a large amount of water is present in the steam, and this is so frequent that no result is worth the time spent that does not embrace all the factors in the first part of No. 4. The calorimeter is at once the most reliable and unreliable factor in the whole, and the so-called "modifications," "improved" and variously-termed traps, called calorimeters, are only to mislead those who suppose a good wooden barrel and scale of no use. The facts are simply expressed, the old-fashioned barrel is as honest and reliable as any, if honestly used, and in a great degree more reliable than any of the "improved" traps so much paraded. Where small quantities are used a small error is a too large factor of percentage, in my own practice 300 or 350 pounds of water are used, to which exactly thirty or thirty-five pounds are added. This makes quick work and does not need any calculus or long formulæ to get results.

Conclusions necessary call for a moment's explanation. Any result for an hour is of no value. Conditions of the atmosphere make a great difference in evaporation, and the amount of moisture in the air is an element of more importance than usually given. Coal burned in ten hours has no place in my results, but the full coal for a week, is taken including "boilers over Sunday" for fire (as is required by the factory mutual mill insurance companies), and all the coal used, in this way all the facts come out.

Some "evaporative" tests of an hour or two on a 500 horse-power engine may be interesting or amusing, but they

cannot be reliable, if we wish to compare the cost of a horse-power for a week or year.

WHAT DOES A STEAM HORSE-POWER COST?—NO. 5.

Coal per I.H.P. per hour, pounds,	2·28	6·05
Cost of coal per ton,	$2.90	$2.25
Pounds of water per I.H.P. actual,	16·84	47·99
Evaporation per pound of coal,	10·31	7·92
Initial steam pressure, absolute,	83·6	94·6
Terminal pressure, absolute,	8·71	17·2
I.H.P.,	151	159
Cost of one I.H.P. one hour (coal), mills,	2·59	6·077
Cost of one I.H.P. twenty-four hours (coal), cents,	6·216	14·58+
Cost per hour (coal), total load (third line above), cents,	39·+	96·62
Pounds of coal per hour for load,	344	961·95
Pounds of coal per twenty-four hours per H.P.	54·72	145·20
Pounds of water per twenty-four hours for one horse-power,	404·16	1,151·76
Water in steam by calorimeter at boiler per-cent.,	2·16	2·26
Water in steam by calorimeter at engine,	3·04	21·16
Comparative cost of 1 H.P. same time,	$1.00	$2·4775
Actual cost of 1 H.P. one year, 308 days, ten hours,	$7·98	$18.72

In this, we have a Corliss condensing engine and an ancient throttling slide-valve, under free exhaust, one factor, about the same horse-power. In studying the columns of comparative cost, item by item, some interesting facts appear: Coal per I.H.P., and cost per ton, water used per horse-power per hour, all show a change, in which some items are best one way or the other. The cost of horse-power per year of 308 days, ten hours each, would make a difference of $1,074 only in each 100 horse-power plan, working on the conditions of the right-hand columns over one under the conditions of the left-hand column, the engine of smaller horse-power paying sixty-five cents per ton more for coal, and using steam of lower initial pressure, but showing better evaporative power and better calorimetric results.

The engine of left-hand column was put up under my direction in 1883. The other one is in Pennsylvania.

WHAT DOES A STEAM POWER COST?—NO. 6.

Coal in pounds per hour, per horse-power, . . .	1·57	7·7027
Cost of coal per ton, ...	$4.35	$2.25
Cost of coal per horse-power per hour, in mills, .	3·4	8·1174
Actual water consumption per horse-power per hour in pounds, ...	13·71	59·618
Pounds of water evaporated per pound of coal, .	10·34	7·92
Steam pressure per gauge, ...	130·	80·
Steam pressure, absolute, ...	144·696	94·696
Terminal pressure, absolute, ...	5·619	70
Initial pressure, absolute, ...	146·341	82
I.H.P., ...	138·056	249
Cost of one I.H.P. for twenty-four hours, in cents,	8·166	19·48
" " " for 308 days of ten hours each,	$10.48	$24.98
Coal per I.H.P. for twenty-four hours, in pounds,	37·68	184·86
Water " " " " " "	329·004	1430 83
Water in steam per calorimeter, at engine, per cent.	2·31	21·14
" " " " boiler, "	1·74	1·87
Duty for twelve months from Log for 100 pounds coal, ...	113,439,331	19,068,000
Comparative duty, ...	5·949	1

Table No. 6, left-hand column, is from the Pawtucket Pumping Engine in 1879, and I am told that Prof. Denton, of Stevens Institute, repeated the test in 1889, with results of nearly the same amount of water per horse-power per hour. The column at the right hand is a pumping engine in Pennsylvania, new in 1887 or 1888. Notice there is a difference of $2.10 in the cost of coal per ton; one engine has over 100 horse-power more than the other; great difference in terminal pressure, as well as initial; one engine using 13·7, the other 59·6 pounds of water per I.H.P., the amount of coal per I.H.P. being 4·9 times as much in one case as in the other; the boilers varying very *slightly* in the amount of water present in the steam at the boiler, very *largely* in that at the engine. Yet in total result the Corliss engine horse-power costs only $10.48 for 3,080 hours, the other engine $24.98.

There can be no better example of Carnot's law of efficiency than in these two engines, and if the Corliss engine had coal at $2.25 its horse-power would be diminished inside of $6 for 3,080 hours, or one-fourth the other pumping machine; and if we consider the ratio of work done by 100

pounds of coal in proportion, the ratio of actual cost between the two engines becomes an enormous one. The duty shown on the screen is not the one at first said to have been made, and which Mr. Corliss denounced as "humbug." The "experts" built a fire, then counted the coal used, and when finished left water, etc., "as at commencement," and pronounced the duty as "133 millions 1 foot high, with 100 pounds coal." Mr. Corliss called it "a humbug," and insisted on a "common-sense" test under the conditions of every-day life. The duty shown on the screen is from the engineer's log-book. A laughable incident in connection with "the reason why Corliss attained such a duty" is worth mention here. The "why" was that "some place about the boiler was filled with coke which, when ignited, became incandescent and so remained for a long time, thus giving out heat for days." The fact is and has been that the engine *was* and, for aught I know, *is* run by Corliss upright boilers; and if any man can stow coke, except in the fire-space, it will be a good plan to know where it can be done.

WHAT DOES A STEAM HORSE-POWER COST?—NO. 7.

Using Back Pressure for Heating.

Cost of coal per ton,	$4.60	$2.20
Coal per I. H. P. per hour, pounds,	2·54	9·65 +
Pounds of water per I. H. P., actual,	26·28	72·
Evaporation of water per pound of coal,	10·84	7·46
Initial steam pressure,	104·6	94·6
Terminal pressure,	24·6	57·6
Total I. H. P.,	542·	346·
Cost of one I. H. P. one hour for coal, mills,	5·2161	9·5638
" " " 24 hours for coal, cents,	12·518	22·95
Cost of coal for the whole load of engine one hour, cents,	282·71	330·91
Pounds of coal per I. H. P. for 24 hours,	60·96	231·6
Pounds of water per I. H. P. for 24 hours,	630·72	1728·
Water in steam by calorimeter at boiler, per cent.,	2·36	1·94
Water in steam by calorimeter at engine, per cent.,	4·16	14·27
Water in back pressure steam by calorimeter, per cent.,	16·4	36·38
Percentage of total power in back pressure,	20·	40·

Cost of 1 horse-power 308 days of 24 hours each, ...	$38.55	$70.69
Cost of 1 horse-power 308 days of 10 hours each, ...	16.48	29.45

The use of back pressures for heating is various as to appliances and purposes—an instance is shown between a Pennsylvania concern, with coal at $2.20 per ton, and a New England (mixed power) cotton mill using coal at $4.60 per ton, and nearly 100 miles railroad haul from water, the coal in left column costs over double that in the right hand one; both engines use back pressure, one to a reasonable, the other to an unreasonable extent, the one has just double the percentage of back pressure in power to total load of the other engine. Both engines are nearly the same I.H.P. if back pressure was reduced, boiler evaporation quite in favor of the large engine, calorimetric conditions at boiler not in its favor, but at the engine twenty per cent. to its advantage.

There are many points of interest in this table over which steam-users can ponder. One of them is that the value of the steam, as a means of doing its work again in boiling, etc., is not represented by the amount of water per calorimeter, but that that percentage is a reduction of "heat of vaporization," or, to use Zeuner's formula, if we have steam at eighty-two pounds and 1·8 per cent. of water, we lose 95 heat units from each pound of steam, and eight per cent. of water 148 heat units, and 12·6 per cent. of water in steam of eighty pounds = 183 heat units loss. So in back pressure of ten and one-half pounds gauge pressure, we lose with five per cent. of water 116 heat units, and at forty per cent. of water 431 heat units lost out of 1,141. The users of this "system" advocate latent heat in its entirety, forgetting that water present absorbs latent heat very rapidly. The calorimetric conditions between the two engines are very different in the three amounts cited, while the conclusion shows that the New Hampshire man pays over double for his coal, yet makes his I.H.P. at $16.48, while the Pennsylvania man's horse-power costs $29.45, with coal at half the money or, to put it in another form, give New

Hampshire his coal at \$2.20, and he will make his I.H.P. for \$8 against Pennsylvania's \$29.45, or nearly, or in comparison, if both men used 1,000 horse-power under present conditions, New Hampshire would save a clear profit of \$12,970 per year, or if Pennsylvania used 2,000 horse-power only, his coal alone would cost \$25,940 more than the New Hampshire man, and if the New Hampshire man had coal at \$2.30, he would make his horse-power for \$8.24 nearly, and save \$21,210 on *1,000 horse-power* over the Pennsylvania man each year.

WHAT DOES A STEAM HORSE-POWER COST?—NO. 8.

An Instance of Pumping Machinery.

Cost of coal, per ton,	\$2 40
Pounds of water per I.H.P. of work per hour,	815·82
Boiler pressure,	80 pounds steam gauge
Initial pressure,	36 pounds, absolute
Back pressure,	21 pounds, absolute
Ratio of back pressure to whole load,	78 per cent.
Steam engine required,	4·7955 times the work
Work actually done,	6·5238 horse-power of steam
To do,	1·36045 horse-power of work
Actual amount of water per I.H.P. steam,	170·52 pounds per hour
Water in back pressure varied from 21 to 40 per cent.	
Cost of one I.H.P. one hour of work, cents,	87·428
Cost of one I.H.P. 308 days of ten hours each as one year,	= \$2,692 78
Cost of one I.H.P. one hour of steam, cents,	18·322
Cost of one I.H.P. 308 days of ten hours each as one year,	= \$564.32
One horse-power costs more than 75 horse-power Corliss engine, in ordinary circumstances, at	$18\frac{822}{1000}$ cents an hour

So far nothing has been shown, but what a side-by-side comparison was made. In the data now on the screen (No. 8), an instance of how far men can and do go in machinery for using steam needs no comparison.

With coal, at \$2.40 per ton, and 815·82 pounds of water per hour for *one* single I.H.P. of steam.

This is not by any means the worst case that could be shown, and the figures will bear thoughtful contemplation. The range of cost for an I.H.P. shown to-night runs from \$7.98 per year of 3,080 hours to \$564.32, leaving out the one

item of $2,692.78 for one I.H.P. of work for same time. The conditions in each case will account for all the difference.

If time permitted, I could exhibit to you cases of locomotives blowing through steam two and one-half to four times what was necessary; electric light and railway enterprises, with results that would make any man turn pale if his pocket-book was involved; steamships that are outlets for coal mines only, and other and curious facts. Steam will not be displaced under a few years. Compound engines, using sixty to eighty pounds of water per horse-power, non-condensing, and twenty to thirty on ships, will not immediately drive out better work.

The horse-power can be made by an admixture of brains in the coal for $8 for 3,080 hours, with Corliss 200 horse-power engine and a fair boiler, coal at $3 for 2,200 pounds, for twenty-four hours a day, $7.50; and in 1,000 to 3,000 horse-power, coal at $2.20, and not over twelve per cent. refuse, $5.60 to $6.20 a horse-power, if 144 hours a week, or $7 for twelve hours a day.

Thanking you for your courteous attention for so long a time this evening, I will say: "Good-night."

REPORT OF THE U. S. NAVAL BOARD,

WHICH CONVENED AT BOSTON, MASS., FEBRUARY 10, 1890, UNDER ORDERS OF THE HON. SECRETARY OF THE NAVY TO INVESTIGATE THE WELDING PROCESS OF THE THOMSON ELECTRIC WELDING COMPANY.

LYNN, MASS., February 13, 1890.

To the Chief of the Bureau of Equipment and Recruiting, Navy Department, Washington, D. C.:

In obedience to an order from the Honorable Secretary of the Navy, dated January 9, 1890, constituting us a Board "to examine into the process in use by the Thomson Electric Welding Company, of Boston, Mass., for welding metals, and to report as to its desirability and adaptability for naval purposes, and particularly for use on vessels of the Navy," we have the honor to make the following report:

The process of welding in use by the Thomson Electric Welding Company has been fully investigated by the Board, both experimentally by tests made in our presence, and by investigation of the theories and principles involved.

We find that at the present time this process renders it possible, practically, to weld wrought iron, cast iron, brass and copper rods, from the size of the smallest electrical conductors in use for distributing purposes to rods of two and a half inches in diameter, and to weld pipes of larger sizes; to weld dissimilar metals, and pieces of different forms of cross-section; to join by welding the ends of wire cables, and to form welded rings of small or large diameter.

The operations necessary to accomplish these results were performed upon several different welders having holding-clamps to suit the work in hand, and being of graduated capacity; each machine handling samples varying by a multiple of ten in cross-section; and while none of them represent a machine for general use, it would be possible to construct one having removable clamps to suit different classes of work. In this way, a small number of welders could be adapted to a wide range of service.

As regards the strength of articles subjected to this process, in a majority of samples tested (several in our presence) the rupture did not take place in the weld itself, but at a short distance from it, in that portion of the metal which had become more or less affected by the heat. This would occur in the same way in the ordinary process of welding.

As all of the welders are similar in general design, one is selected for description—that of 20,000 watts electrical capacity, whose range in welding is from three-eighths inch to one and a quarter inch bar iron, or three-fourths these limits for brass, or one-half for copper.

THE 20,000 WATTS WELDER.

The principle of the operation of the machine is the heating of a point of contact between two masses of metal, due to the passage of an electrical current across the surface of contact. The current used is alternating, in order to avoid the electrolysis that would take place in any other

than an elementary metal, and thus cause lack of homogeneity and consequent loss of strength at the point of juncture. The alternating current is supplied by a converter, which forms the electrical part of the welder, the primary consisting of many turns of wire, with a difference of potential at its terminals of about 300 volts; the secondary containing but one turn—a massive casting of copper—with a large superficial area to avoid the loss due to lack of penetration of the impulses of an alternating current into the interior of conducting masses. The difference of potential at the terminals of the secondary, on open circuit, is in the neighborhood of one volt, thus making the ratio of conversion in the neighborhood of 300 to 1. The core of this converter, like those used in the ordinary converter system for incandescent lighting, is built up of thin laminated strips of soft wrought iron, insulated with tissue paper. The terminals of the secondary are massive copper blocks over which set copper sliding guide blocks, mounted with steel clamps for securely holding the pieces to be welded.

In the preparation for welding, these are placed with the ends touching (they having been roughly formed slightly convex in order that they shall abut near their centres). The current is then turned on, and as the metal becomes hot and finally soft at the contact, the contacts are approached by pressure applied by screw, winch, lever or hydraulic power, until the whole cross-section is at welding heat, and bulges as in ordinary butt welding. The operation requires from a few seconds to two or three minutes, depending upon the size of the work. The burr is removed either by hammering while hot, or in the lathe when cooled. In no case does the heating extend perceptibly more than about the diameter of the rod on each side of the weld. In case of working with easily oxidizable metals, borax is used as a flux.

The welder complete, including converter, clamps and the necessary mechanical part (which in some forms of the apparatus is replaced by hydraulic machinery), is all contained in a substantial iron frame on a cast-iron base. In

order to make the welder adjustable to different classes of work, it is necessary to be able to control the electro-motive force, and therefore the electrical energy entering the primary. This is accomplished by placing a second converter (having a movable secondary) in series with the primary of the welder. In a segment of a split-ring laminated core, are wound several coils which may be connected in series or multiple by means of a switch. Within the annular ring, is an iron armature, and mounted upon this is a heavy brass casting enclosing the annular core and forming a secondary. If this be placed so that it embraces the primary coils, the drop in them will be double (approximately) that which it would be in case the secondary is revolved to the other side of the ring, thus embracing the slit, across which, practically, no lines of force pass. Thus the E. M. F. absorbed in this throttling device may be varied within wide limits, and vary in like proportion the E. M. F. available at the welder. The electrical capacity of this welder being 20,000 watts, the primary E. M. F. being about 300, that of the secondary about one, the efficiency being in the neighborhood of eighty per cent., the current in the secondary, at maximum work, would be about 16,000 ampères. Thus the engine horse-power necessary for this size work is about thirty. It is stated by the electricians of the company that a weld in two and a half inch round bar iron requires about 140 horse-power at the engine. The fact that all parts of the apparatus remain remarkably cool indicates its excellent design.

The dimensions of this machine are: weight, 2,000 pounds; height, 34 inches; floor space, 27 x 7 inches.

We are convinced that the Thomson Welding Process can be found of great utility to the naval service, both on shore and afloat, for the following reasons:

It can be used—

(*a*) In welding breaks in rods without altering them either in length or shape.

(*b*) For welding tubes.

(*c*) For welding angles and shapes of intricate form.

(*d*) For welding copper, brass, cast iron or other metals.

(e) For heating metals for forging, tempering and upsetting.

(f) For welding wire cables.

Under these heads the following may be mentioned as a few of the many applications that would result on shipboard; for welding broken pump piston-rods, valve stems, etc.; for joining wires of iron, copper or other metals or bars of the same, of similar or different shapes or sections; for making joints at angles with bars (T or Y-joints); for mending chain and wire rope; for constructing or joining, end to end, pipe of all kinds, and of large or small diameter; working or joining lead pipe; welding T-connections or elbows into lines of piping; welding safe ends to boiler tubes; repairing boiler tubes; welding eye-rings, and welding these again to bolts or bars; repairing cutting and boring tools without hurting their temper; lengthening or shortening rods or bars; repairing broken cast-iron pieces of machinery or broken cast iron or cast-brass fittings; welding copper electric mains.

This system of welding thus renders easy many operations in the working of metals which with the forge and smith have heretofore been considered impossible.

It is the unanimous opinion of the Board that in the present day of ships constructed almost entirely of metals, and in which every fitting possible is made of metal, such a system as that which has been investigated by us becomes not only desirable, but also a means to economy of expense, time and labor, and would add to the efficiency of the vessel under any condition of service.

This system of welding occupies a position of its own; it is able to do not only a large part of the work of the forge now in use, but also is capable of doing much work that was hitherto considered impossible. By its use, the large accumulation of now almost worthless boiler tubes stored at the navy yards could be made fit for service; and the quantity of spare tubes and of many other stores now carried by ships could be reduced.

As the classes of work at naval stations and on shipboard differ materially, the welders designed for use in the two

places should be constructed for the work that will be required of them; those for use on board ship being especially designed with a view to lightness, compactness and adaptability to general work.

THE ALTERNATING CURRENT GENERATOR.

The alternating current generator used in connection with this electric welding system is a multipolar (having four poles), self-exciting dynamo, or with separate exciter, if desired. The electro-motive force is somewhat above 300 volts; the number of alternations, 6,000. The armature has four coils which are wound on the surface, around heavy projections on the core, each coil covering 90° of the surface of the cylinder.

The armature core is built up of laminæ of soft wrought iron, insulated by tissue paper, the whole being set together under hydraulic pressure between cast-iron headers. Longitudinal holes are bored through the core to allow of ventilation of inside, and the field magnet cores and pole pieces are laminated in order to prevent heating in them, owing to the eddy currents that would be set up by the motion of the heavy core projections on the surface of the armature. Though the field magnets are not compound wound, advantage is taken of the properties of the alternating current to vary the portion of the current, commutated in such a way as to procure either a constant electro-motive force at the poles of the machine under all loads, or to cause it to rise to any desired percentage with the load in order to compensate for drop in the circuits. The dimensions of the machine are: height, 46 inches; floor space, 50 x 31 inches; weight, 1,550 pounds.

The machine might be used in an emergency for lighting purposes. By having it built for the standard E. M. F. of the service, it would be able to supply lights in a detached section or in the whole ship, when the number of lights in use did not exceed its maximum capacity. The dynamo could be built as a direct driven machine, and, output for output, would not greatly exceed the standard machines of the service in size and weight.

The generating dynamo, which supplied the energy for all the welders tested, was also supplying current at the same time to seventy-five sixteen candle-power incandescent lamps arranged in series groups of five each. These gave a steady light, with the exception of a momentary increase in brilliancy, due to the electro-motive force of self-induction on breaking the circuit of the larger welders. The dynamo being self-regulating, the lamps have the proper difference of potential at their terminals under all loads within the capacity of the machine. Of course, with a machine built for the standard electro-motive force of the service, current would simply be supplied to the lamps in parallel, as in the present system of lighting.

These dynamos could not replace the continuous current machines now in use, as motor work on shipboard is a widening field, and there is, as yet, no electric motor of greater power than a small fraction of a horse-power that can be run on such an alternating circuit. Neither could the search lights be worked from such a machine. On the other hand, it would be impracticable by any modification of the existing continuous current dynamos, or by the addition of a pulsating device in the circuit of the continuous current, to adapt it to the circuit of the welder, and thus avoid the special generator that must be a part of the installation for welding.

In illustration of the apparatus used, a set of photographs, giving dimensions and other data, is inclosed.

Very respectfully, your obedient servants,

Commander GEORGE A. CONVERSE, U.S.N.,
Senior Member.

A. S. GREENE, U.S.N.,
Member.

Asst. Naval Constructor S. W. ARMISTEAD, U.S.N.,
Member.

Ensign GILBERT WILKS, U.S.N.
Member.

THE METALLURGICAL ARTS AT THE PARIS EXHIBITION.

BY F. LYNWOOD GARRISON,
Delegate of the INSTITUTE.

[*Continued from vol. cxxix, p. 517.*]

MANUFACTURE OF CEMENT AND CRUCIBLE STEEL.

Prof. Jordan states that the use of *cementation* or *converting furnaces* is somewhat stationary in France. There were, in 1877, thirty-four converting furnaces with an output of 1,717 tons of cement (blister) steel; in 1889, the number of working furnaces was twenty-four and the output was 1,491 tons.

These furnaces are not employed solely for the carbonizing of superior wrought-iron bars, intended for the making of shear steel or tool cast steel; they are also used for adding carbon to certain puddled steels and even to certain cast steels for special purposes.

In reference to *crucible steel*, the official statistics give, for 1877, 101 furnaces with an output of 7,252 tons; and for 1887 only thirty-nine furnaces (containing 501 crucibles) have produced 7,532 tons. The old furnaces, heated by coke fires, and containing two or four crucibles each, are now to be found in a few inconsiderable works; the large steel works employ actually nearly everywhere large Siemens gas furnaces, containing twenty and even forty crucibles.

THE IRON AND STEEL WORKS OF FRANCE

may be divided into four groups—the North, with such works as Anzin, Denain, Valenciennes, Maubeuge; the Centre, with Creusot, Commentry, St. Chamond, Firminy,

Unieux, St. Etienne, Fourchambault; the South, with La Voulte, Bessèges, St. Louis; and the East, with Longwy, Pont-a-Mousson, Stenay and St. Dizier.

In treating the French iron and steel works more in detail, I will not confine myself to describing the exhibits of these works, but will endeavor, as far as my means will allow, to give a more or less descriptive account of some of the most important of these works themselves. Some of the largest works in France, notably Creusot, were not at all represented at the exhibition; it would, therefore, seem obviously a mistake in a report of this kind, to omit to make any mention of such large and important establishments. As I have previously intimated, not having received any official recognition from the French exhibition officials, I have been greatly hampered in collecting reliable and accurate details for the report. I need not, therefore, offer any further excuse for the meagreness of detail with which I have been obliged to treat some of the most important iron and steel establishments in France. The greatest number of large establishments are located in the Centre, in what is known as the Loire Basin. We will, therefore, begin with the most famous, if not quite the largest of these Loire works:

LE CREUSOT.

The Creusot establishment is one of the oldest of all the large steel works in France. Its beginnings were very small; a century ago the spot where these works now stand was a small hamlet of fifty inhabitants, called La Charbonière. In 1782, a small gun foundry was erected there by Louis XVI, and, at a somewhat later period, four blast furnaces were erected. This was one of the first establishments in France at which Watt's steam-engine was used. The importance of Creusot was greatly enhanced, in 1793, when the Canal du Centre was opened, for prior to that date its means of communication with the rest of France were very imperfect. The wars of the First Napoleon created a great demand for guns and projectiles, and Creusot received a fair share of the contracts, thus giving it, until the time when

peace was restored, in 1815, a very large amount of work. The works passed through several hands until 1836, when they were acquired by MM. Schneider Frères & Co., who have owned them ever since, M. Henri Schneider, son of M. Eugène Schneider, one of the original firm, being now at the head of the establishment.

With the introduction of railroads in France, the Creusot Works developed rapidly. Under the superintendence of M. Bourdon, the first steam-hammer was constructed there, and by this means the works were enabled to construct marine engines. During the Crimean War, Creusot turned out seventeen 150 horse-power gunboat engines in seven months.

Shortly after 1860, the plant was much enlarged and improved, new blast furnaces were erected, and an annual output of 150,000 tons of iron was effected.

The Creusot Steel Works date from 1869. In the second part of the war of 1870–71, the works supplied the Government, in the course of five months, with twenty-three batteries of seven guns, on the Reffye's system, made of bronze and two of the same of steel; also, sixteen batteries of Reffye's mitrailleuses; in all, 250 guns and fittings.

Messrs. Schneider & Co. control a number of works, etc., in various places besides Creusot: the collieries of Montchanin and Longpenou (Saône-et-Loire), those of La Machine, near Decize (Nièvre), and Montaud-Saint-Etienne (Loire); the iron mines of Mazenay (Saône-et-Loire), of Laissey (Doubs), Allivard (Isère), and St. George's (Savoy). The ship-yards at Chalon (Saône-et-Loire) and the fire-brick manufactory at Perreuil (Saône-et-Loire). Messrs. Schneider are also interested in the collieries of Beaubrun (Loire) and Brassac (Puy-de-Dôme), in the iron works of Jaeuf (Meurthe-et-Moselle), and in the ship-yards of La Gironde, Bordeaux.

In 1837–38, the entire output of coal from the Creusot works was 60,000 tons and 5,000 tons of pig iron; in 1880–81, it was 579,000 tons of coal and 173,000 tons of pig iron, the production of iron and steel and shop work increased in a proportionate amount.

During the financial year of 1880–81, the consumption of materials amounted to 621,000 tons of coal, 200,000 tons of

coke and 517,000 tons of iron ore. When the whole works are engaged to their full capacity, they are capable of an annual production of 700,000 tons of coal, 200,000 tons of pig iron, 160,000 tons of iron and steel, 30,000 tons of machinery and 30,000 tons of bridge material.

The aggregate area occupied by the works, including stores, gardens, etc., is said to be about 1,000 acres. The works employ 15,500 hands, all told, and 180 miles of railroad, used exclusively for the requirements of the establishment.

It has been claimed that Creusot produces the best armor plate in the world, and judging from the results of some of the recent competitive armor-plate tests, this claim seems well established. Since 1876, when Messrs. Schneider obtained a large contract from the Italian Government, the works have produced 25,000 tons of armor plate, and at present they have sufficient plant to turn out 6,000 tons every year. Some of the plates made at Creusot weigh no less than sixty-five tons. They are at present engaged in manufacturing a number of turrets for the French and Belgian Governments.

The Creusot works, since 1873, have supplied ordnance of various descriptions to the French, Italian, Spanish, Japanese, Chinese and United States Governments, stated to amount to several hundred guns and mortars, ranging from three to sixteen inches in diameter and upwards of some 800,000 shells and other projectiles. The first De Bange guns, of from three to three and one-half inch bore, were made at Creusot. In 1888, the new gun foundry was completed, having facilities for producing guns weighing as much as 120 tons. Some of the largest forgings made at these works were the *hollow* shaftings for the *Magenta*, sixty two feet four inches in length.

Great attention is given to the manufacture of marine engines at Creusot and many of the best ships in the French Navy and Merchant Marine are fitted with their engines; they are at present (1889) building a 12,000 horse-power set for the armored ship *Magenta* and a number of other sets of less power. The aggregate horse-power hitherto built at Creusot amounts to 257,000. At their ship-yards, at Chalon-

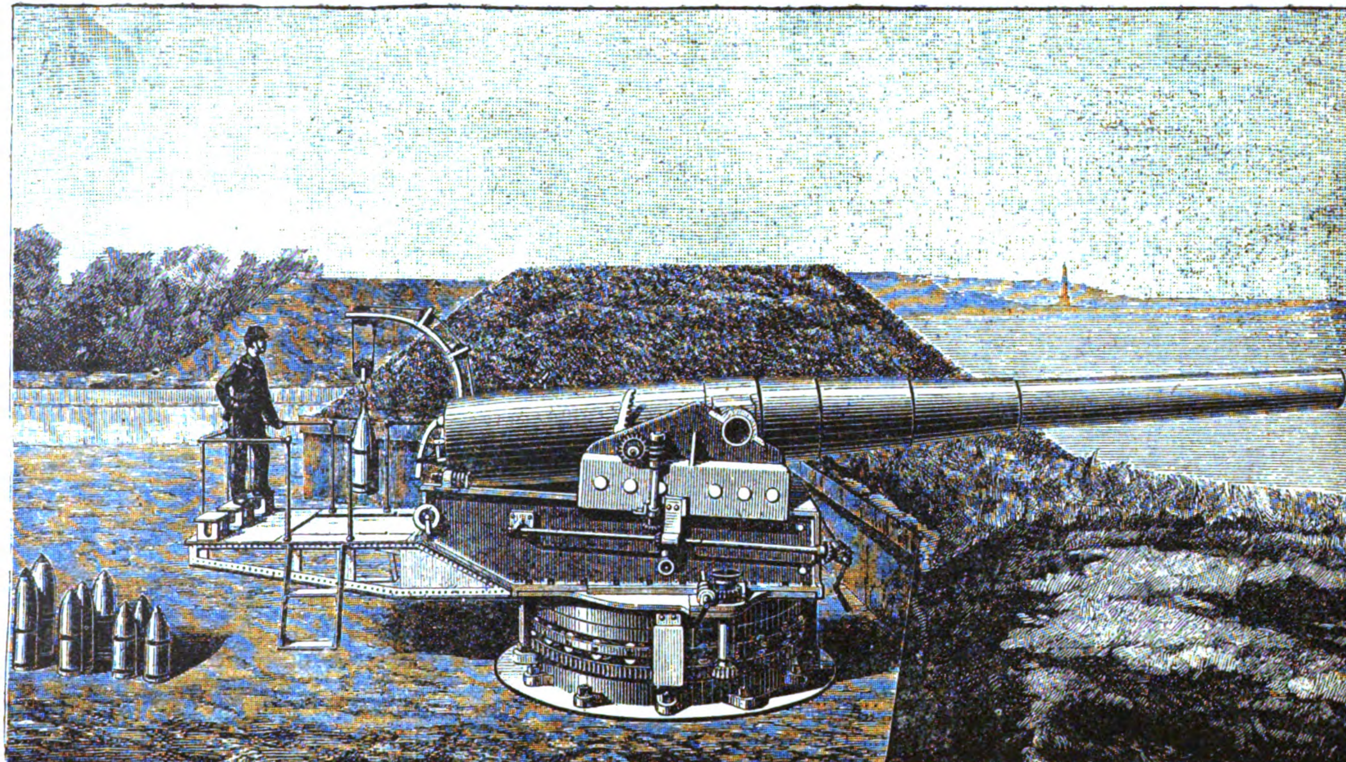


FIG. 1. Twenty-four Centimetre Creusot Gun.

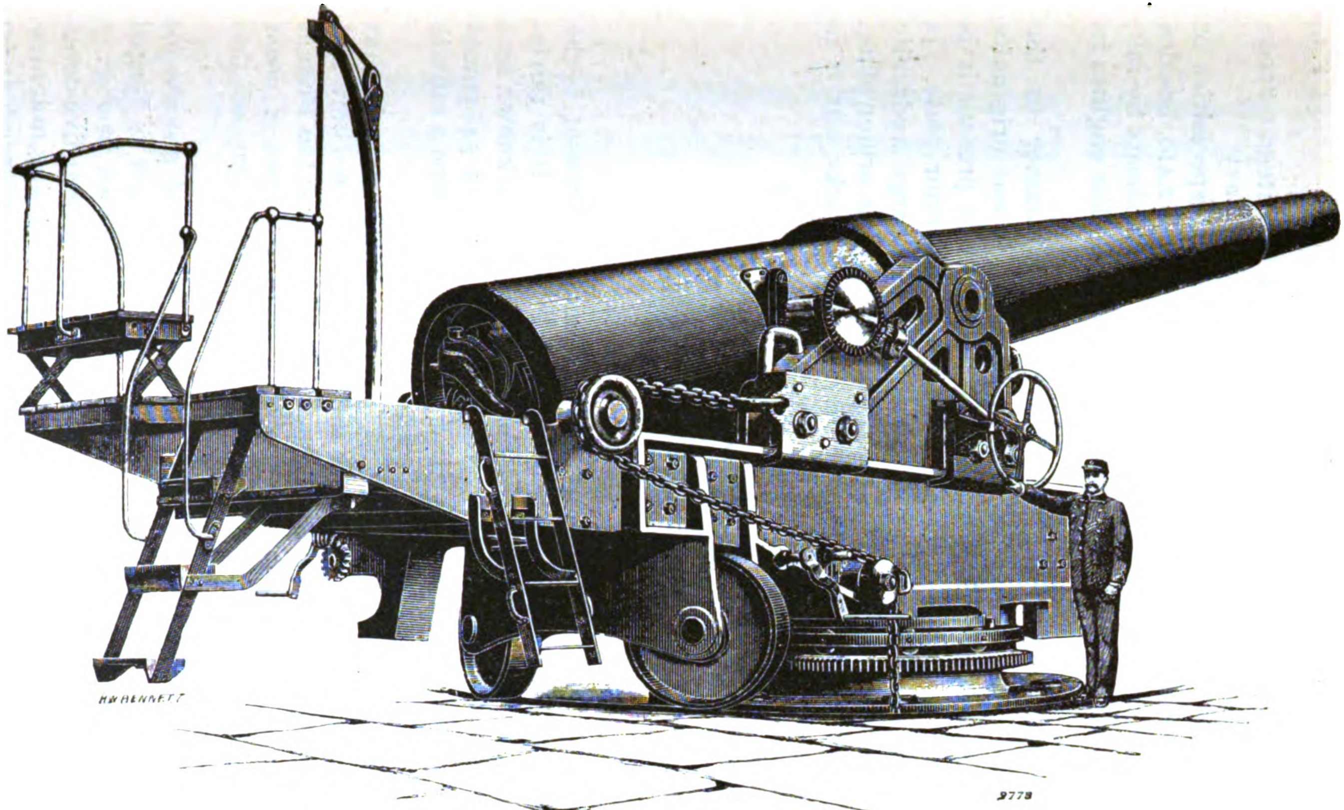


FIG. 2. Thirty-two Centimetre Creusot Naval Gun.

sur-Saône, they have under construction seventeen torpedo boats for Japan and fourteen for the French Navy.

Locomotives are still one of the principal specialties of the Creusot works; so far they have produced 2,416, besides powerful trucks for the conveyance of torpedo-boats by rail. They also have the sole right of building Corliss engines in France.

For several years the largest steam-hammer in the world was the 100-ton one at Creusot; it was originally intended for heavy ordnance forgings, but at present it is mostly employed for the manufacture of armor plate. It is intended shortly to supplement it by a large hydraulic press, such as is used in England for forging armor plate. There is already a 6,000-ton press at these works, but it is chiefly used for bending heavy plates.

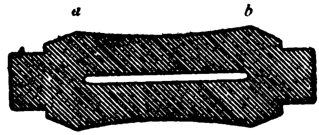


FIG. 3.

One of the best types of guns made at Creusot is the twenty-four centimetre, represented in *Fig. 1*. It is thirty-six calibres in length and is mounted on what is known as a hydraulic, central pivot coast carriage. With a 348-pound projectile and 191 pounds of powder it develops a muzzle energy of 2,200 feet per second.

A rather peculiar type of gun made at Creusot is that represented in *Fig. 2*. It is thirty-two centimetres bore and is the type at present constructed at Creusot for the French Navy. The illustration shows it mounted upon a coast carriage with hydraulic brake; the total weight of this carriage is 45,227 kilos.

Messrs. Schneider use at Creusot a patented process for working out their trunnion hoops. The ingot is forged into a shape having a cross section, as shown in *Fig. 3*. When the forging is cold, a longitudinal slit (*a b*), five-centimetres in width, is cut by means of a mortising machine. The piece is again heated and this aperture enlarged under

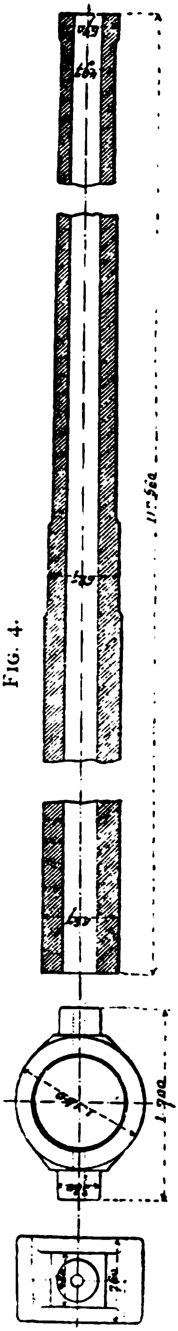


FIG. 4.

the hammer and brought to a circular form by means of appropriate mandrels. The hoop, when turned, bored and finished, is shown in *Fig. 4*.

Creusot Copper Steel.—Messrs. Schneider have patented a process,* which consists in making in a blast furnace, a cupola or a reverberatory furnace, castings containing a variable amount of copper with a less variable proportion of the ordinary elements. These castings are used for the manufacture of copper steel for armor plate, ordnance, projectiles, steam cylinders, etc., these articles being hardened or tempered in oil.

The copper ore is mixed with the charge in the cupola, or else copper filings can be mixed with the coal to form a copper coke which is then used in melting the iron in a blast furnace or cupola. Copper compounds may also be melted in a reverberatory furnace, with a mixture of iron or steel under a layer of anthracite to prevent oxidation.

This subject is one of so much importance that it deserves the most serious attention, and it has been deemed expedient to reprint in this connection the following article which was recently published in the *Journal of the Iron and Steel Institute*: †

"It has long been a matter of discussion whether true alloys of copper and iron can be produced, and great divergence of opinion has existed as to the influence exerted by small quantities of copper on the mechanical properties of iron and steel. As evidence on this point, attention may be

* English patents, 16,568 and 16,569. 1888.

† "Influence of Copper on the Tensile Strength of Steel." By Edwin J. Ball and Arthur Wingham. No. 1. 1889. p. 123.

drawn to the views expressed by Mushet, Rinmann, Berthier, Karsten, Willis and Percy, the general opinion appearing to be that copper renders iron and steel red-short. Jars,* writing in 1774, observes: 'It is generally thought that copper is a pest for iron,' but he adds that he had been told by Cramer, that small quantities of copper had been found by him to improve the quality of iron, and that even one per cent. could be added without destroying the welding power of that metal. Such experiments as have hitherto been made in connection with this subject were but imperfectly supported by analytical evidence as to the composition of the alloys produced, but the earlier of the experiments above referred to were made before the necessity of submitting metals to rigorous mechanical tests was well understood.

"This divergence of opinion led us to believe that it would be interesting to obtain some definite results connected with this subject. A series of experiments was, therefore, instituted to ascertain the effect produced by varying quantities of copper on the tensile strength of steel. In beginning these experiments, it appeared desirable to prepare, in the first place, an iron rich in both copper and carbon, and then to alloy this with a metal containing but little carbon. The metal chosen for the latter purpose was a variety of basic Bessemer steel, the analysis of which was as follows:

BASIC BESSEMER STEEL.

	Per Cent.
Copper,	none.
Carbon,	0·133
Manganese,	0·284
Silicon,	0·002
Phosphorus,	trace
Sulphur,	0·06

"The iron, rich in copper, was produced by melting pig iron, and then adding to the molten metal oxide of copper. The carbon and silicon acted as the reducing agents for the cupric oxide, and the copper was thus introduced into the iron by a 'reaction,' and not by simple solution. A part of

* *Voyages Métallurgiques*, Lyons, 1774, vol. i, p. 4.

the other impurities in the pig iron was also burnt out in this manner, and a metal (A) was obtained which had the following composition:

METAL A.

	Per Cent.
Copper,	7·550
Carbon,	2·720
Manganese,	·290
Silicon,	·036
Phosphorus,	·130
Sulphur,	·190

"This metal was bright, white in color, crystalline, and very hard, but it did not offer any great resistance to impact. Varying quantities of it were then melted down with the basic Bessemer steel previously mentioned.

"The products of these fusions were allowed to cool very slowly, the crucibles in which the fusions had taken place being permitted to remain in the furnace until quite cold. Test-pieces, 1 x $\frac{1}{4}$ x $\frac{3}{16}$ inch, were then cut, and submitted to tensile tests in a multiple lever testing machine, the test-pieces being first carefully annealed.

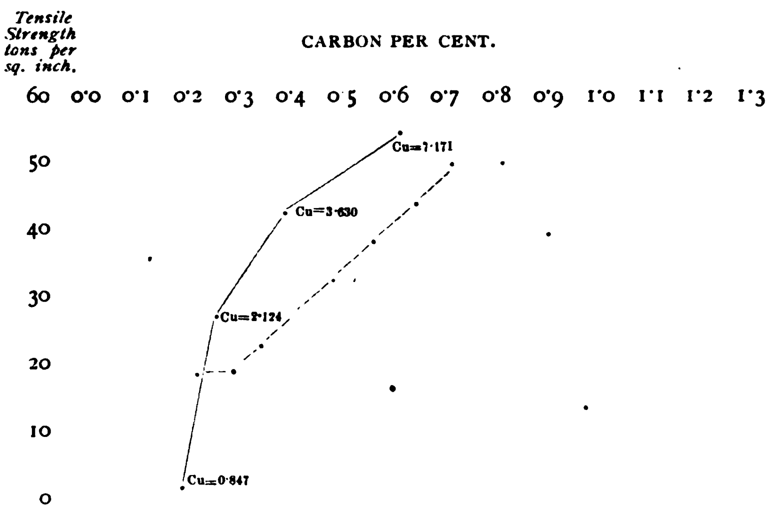
"In the alloys produced in this manner the percentages of carbon and of copper necessarily increased simultaneously. It would, of course, have been desirable to test the influence of varying quantities of copper or steels which contained gradually increasing percentages of carbon, but such experiments would entail a lengthened investigation, and we have therefore, considered it sufficient, in this preliminary examination, to obtain evidence as to the influence of copper on iron in the presence of gradually increasing quantities of carbon, which might form a basis for a further examination of the question.

"The following table shows the percentages of copper and of carbon in the metals tested, and the results of the tensile tests of the various specimens:

Test-Piece. No.	Copper. per cent.	Carbon. per cent.	Tensile Strength. tons per square inch.
1,	0·847	0·102	18·3
2,	2·124	0·217	36·6
3,	3·630	0·380	47·6
4,	7·171	0·712	56·0

"The total elongation of the test-pieces was also noted, but owing to their small size the results are not trustworthy. The elongations observed, however, were as follows: Test-piece (1) ten per cent.; (2) five per cent.; (3) five per cent.; (4) showed no visible extension, or the extension was but very slight.

"In the following table are shown, in the form of a curve, the tensile strengths given above, as well as those which are considered by Mr. R. Gatewood* to represent the strengths of ordinary steels of varying degrees of carburization, the latter curve being shown by dotted lines:



"It will be observed that the tensile strengths of the specimens containing copper are greater than those of the specimens in which no copper is present. Where the turning-point of the curve would be in the case of the cupriferous series, we are unable to say, as other samples which were prepared, and which contained more carbon than the above, were so hard that test-pieces could not be cut. That copper increases the tensile strength of iron is also apparent from the following results:

* *Journal of the Iron and Steel Institute*, 1887, vol. i, p. 444.

Description.	*Copper. per cent.*	*Carbon. per cent.*	*Tensile Strength. tons per sq. inch.*
Original steel.	—	0·133	29·0
Test-piece 5, ...	4·10	0·183	43·2
Test-piece 6, ...	4·44	trace	34·3

"This latter metal did not, however, appear to be perfectly homogeneous, and it was observed throughout these experiments that the simultaneous presence of carbon appeared greatly to assist in the more intimate association of the copper with the iron in which it was dissolved.

"Observations of the fracture showed that of test-piece 1 to be somewhat fibrous, whilst those of 2 and of the remaining samples were highly crystalline. The fracture of sample 6, which contained no carbon, was very irregular, the metal being of a bright gray color and highly crystalline. The fracture of specimen 4 was very finely granular and close.

"Besides determining the tensile strengths, forging tests were also made. Some of the specimens, comparatively poor in copper and carbon, appeared to forge fairly well both cold and hot, and this was the case with specimens 1, 2, 3 and 5. No. 4 forged well in the cold, but was red-short, which is to some extent in accordance with the views expressed by the older writers. The results cannot, however, be considered very reliable, owing to the small quantity of the material that was at our disposal for the purpose of these tests. The principal effect that the presence of copper appears to exert on iron and steel is to render it extremely hard. This was peculiarly evident in the case of specimen 6, which was free from carbon, but contained 4·44 per cent. of copper, and was so hard that it could scarcely be cut by a good hack-saw. Owing to this great hardness, and to the comparatively good results of the forging and tensile tests, we hope that further tests of the crushing strengths of these metals may lead to the results being of interest from a practical point of view.

"The opportunity afforded by the preparation of the metal A was taken for observing the order in which the carbon, sulphur and silicon originally present in the pig iron were eliminated by the oxygen of the cupric oxide added,

the percentage of sulphur in the metal having been largely increased for the purpose of this experiment, which consisted in melting the iron in a graphite crucible, and then making successive additions to it of cupric oxide. After each addition of the oxide, the metal was poured, a sample taken for analysis, and the remainder charged into the crucible again and remelted, a further addition of cupric oxide being then made.

"The following table shows the composition of the pig iron used, as well as that of the samples taken after each successive addition of cupric oxide:

Description.	*Silicon. per cent.*	*Carbon. per cent.*	*Sulphur. per cent.*
Pig iron,	1·02	2·60	1·44
First sample,	0·55	2·32	1·27
Second sample,	0·10	2·02	1·12
Third sample,	0·05	1·77	1·18
Fourth sample,	trace	0·61	1·08
Fifth sample,	trace	0·34	0·85

"It will be observed that whilst the silicon was rapidly oxidized, the carbon was only appreciably attacked after nearly the whole of the silicon had been eliminated; and, further, that the percentage of sulphur was not greatly affected till most of the carbon had been burnt off. This diminution in the percentage of sulphur may, however, to some extent be accounted for by the dilution of the pig iron by the copper reduced from the cupric oxide.

"From a general consideration of the results of our experiments, it would seem that within certain limits copper does not prejudicially affect the mechanical properties of steel, and this to some extent agrees with the theory recently put forward by Prof. Roberts-Austen,* and supported by much experimental evidence, that small quantities of a metallic impurity only exert a deleterious effect on a large mass of another metal if the atomic volume of the impurity is greater than that of the metal in which it is hidden; and that if the atomic volume is either about the same or smaller, it will either exert no appreciable dele-

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* *Proceedings of the Royal Society*, vol. xliii, 1888, p. 425.

terious effect, or else act as an improver. The atomic volume of copper is nearly the same as that of iron. In our experiments, however, the percentages of copper were considerably higher than those which Prof. Roberts-Austen contemplates."

COMPAGNIE ANONYME DES FORGES DE CHATILLON ET COMMENTRY.

This company was founded in 1845, has a capital of 12,500,000 francs and is stated to have no funded indebtedness whatsoever. They have blast furnaces, steel and construction works at Montluçon-Saint-Jacques (Allier), blast furnaces and mills at Commentry (Allier), blast furnaces at Beaucaire (Gard) and at Villerupt (Meurthe-et-Moselle), rolling mills, wire and nail works at Sainte-Colombe, Ampilly, Mussy and Chamesson (Côte-d'Or), Plaines (Aube), Morat (Allier), Vierzon (Cher), and a wire-rope manufactory at Français (Allier). The company have besides collieries, iron mines and quarries at various places. The range of their products includes almost every article made of iron or steel, but, like all the great steel works in France, they made a specialty of war material. Since 1867, they have supplied the French marine with very large quantities of iron, steel and compound armor plates and to the French and Belgian Governments a number of large turrets for the armament of forts.

The Châtillon et Commentry Company's exhibit was in two parts. The part devoted more exclusively to commercial products was in the same section as the exhibits of the other iron and steel works of the Loire Basin, whilst that of the war material was in the pavilion of the Minister of War. The display of commercial articles was extensive and interesting, consisting of angles, beams, tires, wire rope, wire nails, etc. A fine lot of excellent steel castings of various sizes were also shown. By far the most interesting part of the exhibit was that of the war material. Since 1867, the Châtillon et Commentry Company have given special attention to armor plate. In 1880, when compound armor was adopted by the French Navy, this company was one of

three French concerns who acquired the right to make what was known as the "*Cammell compound plates.*" The company, however, does not confine itself to compound plates, as *all-steel* plates are now receiving the most serious attention. A portion of the exhibit in the pavilion of

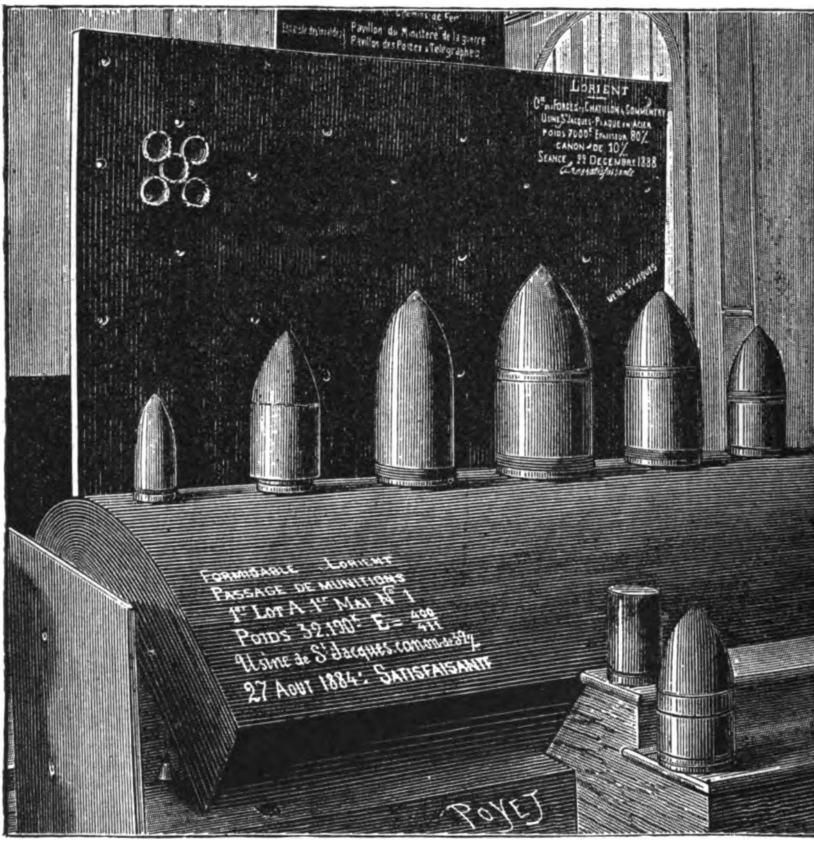

FIG. 5.

the Minister of War, is shown in *Fig. 5*. *Fig. 6* shows part of an iron plate, one-half metre thick, weighing 34·6 tons, tested at Gavres, in 1886, giving the most satisfactory results. In *Fig. 5* is shown a compound plate made for the *Formidable*, weighing 32·19 tons, tested in 1884 with satisfactory results.

The Châtillon et Commentry Company have made a specialty of soft and extra soft steel plates, to be used where glancing shots are apt to strike.

Perhaps the most interesting development which this company has recently made in the metallurgical art is the *process of tempering steel in molten lead.*

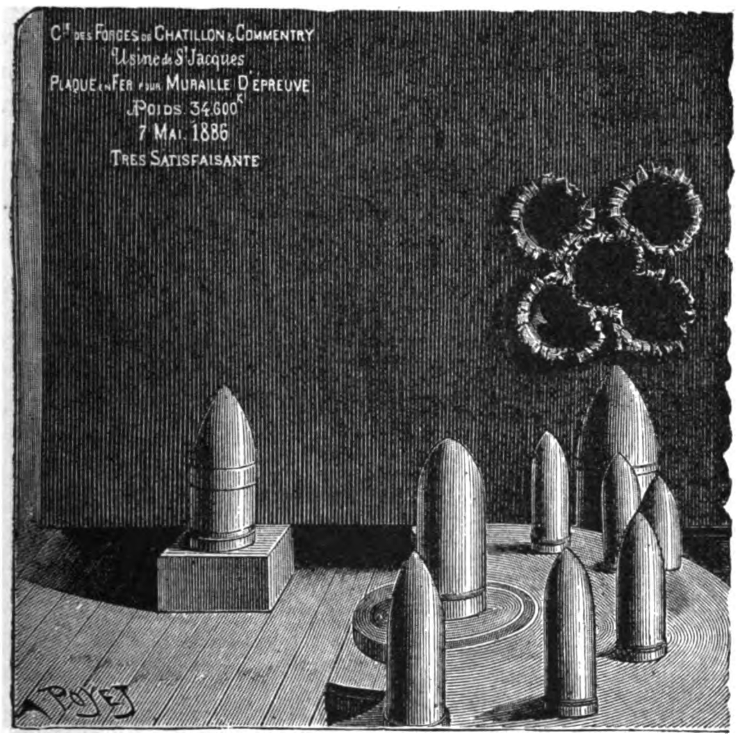

FIG. 6.

For many years it has been a somewhat common practice to use baths of the easily fusible metals or alloys for quenching steel, but never before has it been attempted on so large a scale as at present in use at the works of this company. An excellent article on the subject of tempering in molten lead at the Châtillon et Commentry Company's works, was published in a recent issue of the *Iron Age;** it

* October 10, 1889.

was thought of sufficient interest to present the following data from the same:

The company has established a special plant for this purpose, and has experimented exhaustively and intelligently on the subject. In a special report by M. Evrard, General Manager, it appears that the size of the lead-bath has been increased, until now it is capable of holding 250 tons of lead. The temperature is varied considerably according to the kind of steel operated on, and the depth and volume of the bath must be changed, which it seems is done by filling in parts of the space otherwise occupied by lead. From the report of M. Evrard and articles by E. Lisbonne in the *Génie Civil*, we gather the following data:

Starting on hammered steel, shells made of steel carrying about one per cent. of carbon yielded the following results, bars being cut from the cold metal:

	Limit of Elasticity. kg.	*Tensile Strength.* kg.	*Elongation.* per cent.
Tempered in lead:			
No. 1, ...	50	81	9·5
No. 2.	47	84	9·5
No. 3, ...	48	91	7·75
Average, ...	48·4	85·4	9
Tempered in oil:			
No. 1, ...	47	83	6
No. 2, ...	45	73	7·5
No. 3.	44	73	6
No. 4, ...	45·4	85·4	6·5
Average, ...	45·4	76·4	6·5

Shop-tests were carried on on bars 30 x 30 cm. placed on supports 160 mm. apart, an 18 kg. trip-hammer being used. The distance of the fall was increased at each blow 10 cm., starting at a height of 50 cm. In the case of the steel tempered in lead, rupture resulted at a height of 2·80 m. in the two first cases, and 2·40 m. in the second, while in the case of shells tempered in oil the figures were 2·10 m., 2·20 m., 1·90 m. and 2·07 m.

On gun tubes which were made at the works from soft steel the process does not seem to give a notably better result than that used in ordinary manufacture. It simply has the advantage of doing away with reheating.

The first experiments made by the Commentry Company on armor was on parts from two plates carrying 0·54 to 0·64 of carbon. In the case of the former the resistance from rupture rose from 6·2 kg. to 7·6 kg., and the elongation, which was 15·5 per cent., dropped to 9·5 per cent. In the case of the steel containing 0·64 carbon, the resistance rose from 77.3 kg. to 88 kg., and the elongation, which was 10·5 per cent. before tempering, was 13 per cent. after it. On compound plates the steel of which carried 0·73 carbon, the plate merely reheated showed an elastic limit of 39 kg., a tensile strength of 80 kg., and an elongation of 10 per cent. When tempered in lead the elastic limit rose to 58 kg., the tensile strength to 95 kg. and the elongation to 12 per cent. On soft steel-plates two specimens carrying 0·30 carbon showed the following: The limit of elasticity was increased from 25·7 kg. to 28 kg., the tensile strength from 5L4 kg. to 53 kg., while the elongation was reduced from 25 per cent. to 23 per cent. M. Evrard states that in all soft steels which have been rolled there is very little increase of resistance from the tempering by lead. The most notable result is an increase of the ballistic resistance, as was proved by our trials with guns which we will mention further on. He claims, however, that on soft steels merely cast, immersion in metallic baths has a most marked effect. The grain is as completely changed as if it were done by forging, and resistance to shock is increased to a notable degree. Our ballistic experience on merely cast and tempered plates give about the same results as those on rolled plates. He urges that herein lies one of the most important applications of the process to the manufacture of armor plates, and besides to all kinds of cast metal, on account of the increase or resistance due to the use of this method of tempering.

The first experiments of the target practice at the Sainte-Jacques Works were all made under identical conditions so as to facilitate comparison.

The plates tested measured 1·500x0·735 and 0·726 m. The cannon used was of 95 mm. calibre, firing at a speed of 416 m. cylindrical projectile, with blunt cone point of chilled iron or chrome steel, weighing 11·4 kg. The shots were fired at

the four corners of a lozenge-shaped plate, whose sides were twice the length of the calibre—*i. e.*, 19 cm. After the first four shots, the remaining shots were fired on the same four spots in the order of the first firing.

The results of these experiments were as follows: An iron plate which was tested as a sample gave a mean depression for the first four shots of 132 mm. and for the following shots of 198. It was cracked by the seventh shot and completely broken in two by the eighth shot. A hard steel plate tempered in lead showed a mean depression of 99 mm., while a non-tempered steel plate showed 105 mm. The number of shots, before rupture, was six for the first and only five for the second, but this result for the tempered plate must be attributed to a lateral flaw which occasioned a premature crack, otherwise it would undoubtedly have stood eight or more shots. Two rolled plates of soft metal showed about the same depression (111 mm. and 112 mm.); only the first was able to withstand one more shot. It was broken by the seventh shot and the second by the sixth. A plate of simple cast steel tempered in lead gave the same results as the rolled and tempered plate. It withstood seven shots, with a depression of 113 mm. A cast and non-tempered plate, tested for comparison, broke at the fifth shot with 119 mm. depression. Two compound plates, tempered and not tempered, presented about the same results as to depression (89 mm. and 83 mm.); the tempered plate stood ten shots and the trial was only stopped by the crumbling of the outer layer of the plate, which was badly welded. The plate not tempered, made of extra-hard steel, broke at the third shot.

The first trials prove very forcibly the influence of the process on the manufacture of armor plates, especially those of hard steel; resistance to penetration and stiffness are increased without any resulting brittleness in the metal. With pieces in soft metal merely cast, we are able to obtain a resistance equal to that of forged pieces.

The company have tried to determine the influence of the process of immersion on metal, independent of their ultimate use. For the tests bars were cast into uniform

shapes, 120 x 120, which were then rolled into blunt cones, 40 x 40. Each metal bar thus used was tempered in a lead bath, at about 400° C., the bath being composed of about ten times the weight of the bar immersed. The temperature of the bars varied according to the nature of the steel, but efforts were made to keep it a little above the point B of the Chernoff classification. The other part of the bar was reheated in the ordinary manner, *i. e.*, two hours red-hot, then cooled in dry sand. Next, the bars, which had served for the tensile strength and shock tests, were cut from the cold metal. These tests were applied under the ordinary rules governing the artillery service, and were made on five different kinds of steel--carbon, silicon, manganese, chrome and cement steel. These experiments established the following facts:

(1) *Carbon Steel.*—Even for this class there is quite an increase of the limit of elasticity. This increase goes as far as thirty per cent. For the harder metals it is generally less, and is about twenty or twenty-five per cent., except for the carbon and manganese steels, where it attains forty per cent. In the soft steel the diminution of elongation is imperceptible. In metals having from 0·45 carbon there is a mean result of thirty-eight per cent. elongation before tempering, varying from ten to fifty per cent. In the shock-test there is an increase of stiffness in the metal according to its hardness. The brittleness after tempering is less, while the tempered bars withstand more shots than those not tempered.

(2) *Silicon Steel.*—Only a few tests have been made with this class of metal. The limit of elasticity, however, after tempering, shows an increase of seventeen to thirty-two per cent. The increased tensile strength is about sixteen per cent. The diminution in the ductility is thirty per cent.

(3) *Manganese Steel.*—The increase of the limit of elasticity after tempering varies from twelve to seventeen per cent. The increase in resistance is from sixteen to twenty-three per cent. The diminution of elongation attains fifty-three per cent.

In the manganese as in the silicon steel, the tempering

by lead increases its stiffness in the shock tests. The number of hammer strokes withstood is about the same for the tempered as for the metal not tempered.

(4) *Chrome Steel.*—In this class of metal the bars tempered were reheated to a dull red. For the most part it was impossible to get at the limit of elasticity after tempering, but it seemed to increase from ten to eighteen per cent. The tensile strength presents a relatively small increase as compared with the preceding metals. This fact is explained by the reheating after the tempering. This increase varies from ten to twenty-two per cent. for widely differing classes of the metal. As for the diminution of elongation, it is less than for the foregoing metals. It is about twenty-one per cent. In the shock-test a noticeable increase of stiffness was observed. The steel after tempering is less brittle and withstands before rupture a greater number of hammer blows.

(5) *Cement Steel.*—The increase of the limit of elasticity by tempering is twenty-one per cent. The increase of resistance is about seventeen per cent. The diminution of elongation is twenty per cent. less for steel carrying less than one per cent. carbon. In the shock test there is quite a notable increase of stiffness, while the metal does not seem to be more brittle after than before tempering.

It is claimed that the fact was proved that even for the harder steels (providing they were perfect at the start) there was no fear of flaws caused by the process of tempering. A chilled cast-iron shell, with 3·50 carbon, which would not have stood the ordinary tempering with oil or water without cracking, came out of the immersion in lead perfect.

Experiments on steel tires are claimed to have proved the advantages of tempering with lead. By submerging steel tires which had been refused by the principal railroads in the lead bath, it was possible (when they were perfect at the start) to put them in condition to fill all requirements of contract. As an example, tests applied to a lot of steel tires for the Lyons and the Orleans railroads are quoted.

Comparative tests were made on fifteen tempered and fifteen tires not tempered. The test applied was the fall of

a 1,000-kg. hammer, from a height of 10 m., on each tire placed horizontally. These tests gave the following results:

	Tires not Tempered.	*Tempered Tires.*
Rupture, ...	3·6 blows (mean).	4·5 blows (mean).
Depression caused by first blow, . .	98 mm.	74·6 mm.

It is claimed that this shows that the tempering increases the stiffness of the metal and its resistance to rupture. The tires thus treated were in condition to be accepted by the railroad company.

M. Evrard sums up the results as follows: "By the lead-tempering process, under conditions indicated above, a mean increase of twenty per cent. in the limit of elasticity may be counted upon; also an increase of eighteen per cent. in the tensile strength. These increases are more pronounced in the carbon steels than in any other. The minimum of increase was found in the silicon steel series. The diminution of elongation was greatest in steel high in manganese; it was the least perceptible in the chrome steel. As regards the shock test, the stiffness is increased without rendering the metal more brittle. It is from these data that each works must determine for itself the article or articles it manufactures which are most liable to gain by the application of this process of immersion in metallic baths."

The following table of tests of water-quenched, oil-quenched and lead-quenched bars is given by Henry M. Howe, in his work on iron and steel metallurgy, as results obtained by the Châtillon et Commentry Company:

PROPERTIES OF STEEL ANNEALED AFTER DIFFERENT KINDS OF HEAT-TREATMENT—CHATILLON ET COMMENTRY.

Number.	Per Cent. of Carbon estimated.	Tensile strength, pounds per square inch, when annealed after				Elastic limit, pounds per square inch, when annealed (?) after				Elongation, per cent. in 8 inches, when annealed after			
		forging.	quenching in water.	quenching in oil.	quenching in lead.	forging.	quenching in water.	quenching in oil.	quenching in lead.	forging.	quenching in water.	quenching in oil.	quenching in lead.
1	0·10	44,090	51,628	—	—	26,170	35,130	—	—	30	20	—	—
2	0·20	43,379	64,429	48,499	44,375	25,601	48,357	36,979	26,738	34	28	30	31
3	0·30	65,567	80,785	71,256	72,251	36,979	52,340	41,815	43,806	24	21	24	22
4	0·40	70,402	88,039	81,496	74,100	39,112	59,024	53.477	45,939	20	18	22	21
5	0·50	77,941	105,391	98,706	86,190	43,806	72,251	65,567	51,486	21	15	19·5	20·5
6	0·60	85,336	112,360	102,404	89,603	46,935	81,070	70,402	53,193	18	13	17	17
7	0·70	91,026	126,583	113,782	99,559	52,624	88,181	7 ,958	61,158	16	14	14	16
8	0·80	93,870	137,961	119,472	106,671	54,046	92,448	76,803	56,891	17	11	13	14
9	0·90	98,137	140,806	123,739	108,093	54,046	93,870	79,647	64,002	16	10	13	15
10	1·00	106,671	153,606	129,428	115,205	55,469	106,671	81,070	69,691	17	10·5	11	15
11	1·10	113,782	163,562	145,072	129,428	56,891	116,627	92,448	79,647	14	7	9·5	12
12	1·20	122,316	170,674	163,562	150,761	64,002	128,005	115,205	98,137	12	8	9	10
13	1·30	1.8,005	180,629	163,562	156,451	69,691	125, 61	116,627	95,292	10	6	9	10

Thirteen sets of one and one-eighth-inch square steel bars, apparently eight inches long between marks, each set being of constant composition, are tested tensilely in four different conditions. These conditions are as follows:

(1) Simply annealed, apparently by slow cooling from dull redness after previous forging.
(2) Quenched in cold water from about W. (b of Chernoff), then reheated to 750° F. (400° C.) and cooled slowly.
(3) The same, except that they are quenched in oil instead of water
(4) The same, except that they are quenched in molten lead instead of water.

The proportion of carbon is approximately that given in the second column, and but little silicon, manganese, etc., is present, *i. e.*, the metal is true carbon steel.

The large universal rolls used for rolling armor plate, at the Saint-Jacques works at Montluçon are shown in *Fig. 7*. The horizontal rolls are one metre in diameter, 5·80 m. long, weighing 30,000 kilos each. They will roll a plate 1·20 m. thick, under ordinary circumstances, and with some modifications a thickness of two metres can be obtained. The standards for housings are 4·30 m. apart and 4·70 m. high. The lower roll is fixed, and the upper one is movable in a vertical direction. The bearings of the lower roll are beneath the level of the floor. The bearings holding the upper roll slide up and down within the standards. This roll is balanced by counterweights arranged below the bed-plate, the action of which tends to bear up the roll; the displacement is regulated by pressure-screws passing through the standards. By this means, the axis of the upper roll can be adjusted at various angles to the horizontal axis of the lower roll; thus, plates can be rolled having an inclined surface on the one side.* Either both ends of the upper roll can be moved together in the ordinary way, or one end may be raised or lowered while the other is stationary; or, lastly, both ends may be moved simultaneously in opposite directions.

Another new feature is an arrangement of the driving pinions which keeps the spindle of the top roll horizontal at all positions. This is effected by using two intermediate pinions, of which the lower one, driven by the bottom roll, runs on fixed bearings attached to the front of the pinion-housing, while those of the second are carried in a curved guide, allowing a small amount of motion concentric to the first pinion. The axis of the second pinion is in its turn connected by radial bars with the bearings of the top-roll pinion, so that the latter is raised or depressed by the setting screw which is similar to those attached to the rolls; the axis of the second pinion slides in and out in the link, and remains in gear with it as well as with the one below. In this way

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* An elaborate description of these rolls was published in *Le Génie Civil*, September 21, 1889, pp. 489–492.

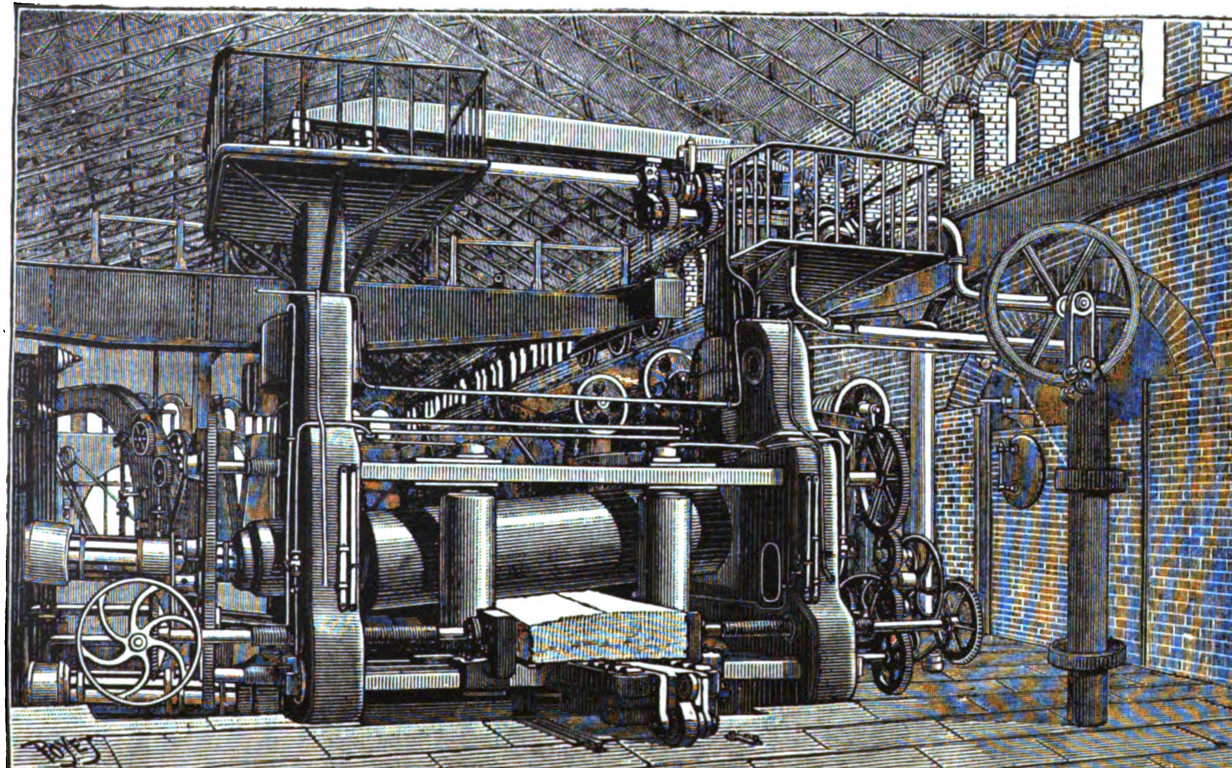

FIG. 7. Universal Rolls for Armor Plates (St. Jacques Works).

the coupling-spindle is kept horizontal throughout the whole range of the top roll, which may be brought down to within a half inch of the bottom one or raised over six feet from it.

[*To be continued.*]

ON SCHOOLS: WITH PARTICULAR REFERENCE TO TRADES SCHOOLS.

BY JOSEPH M. WILSON, A.M., C.E.
President of the FRANKLIN INSTITUTE.

[*Continued from vol. cxxix, p. 498.*]

Mechanics.—This is in the list of specific subjects, and in 1884 it was decided to try the peripatetic plan of teaching mechanics in some districts in London. This was commenced in June, 1885, in twenty schools. A lesson is given fortnightly by the science demonstrator, to the boys in the fifth and higher standards, the lesson being illustrated experimentally by specimens and apparatus carried from school to school. Between the visits of the demonstrator, instruction is given to the boys by a teacher who was present at the demonstrator's lesson. In consequence of its success, this plan was extended in 1887, and three additional demonstrators, appointed for three years, as a further experiment.

Kindergarten instruction is used in the infants' department.

Bible instruction is given and religious observances may be carried out, provided, however, always, that the provisions of the acts on public elementary schools, in reference to religious matters be strictly adhered to.

Object Lessons.—As early as 1871 the course of instruction included object lessons, embracing in the six school years a course of elementary instruction in physical science and serving as an introduction to the science examinations conducted by the Science and Art Department. In November,

1878, a scheme was adopted for object teaching, but object lessons had not been as yet recognized in any way by the Education Department. In June, 1881, however, a memorial was presented, asking that object lessons should be fully recognized and considered as an essential part of the instruction in infant-schools, and as a result, the code of 1882 specified that in assessing the merit grant in infants' departments, regard was to be had "to the provision made for * * * simple lessons on objects and on the phenomena of nature and common life." It also recognized as a "class subject" in the upper departments, elementary science, which was defined as "a progressive course of simple lessons * * * adapted to cultivate habits of exact observation, statement and reasoning." Object teaching is now part of the regular course; inspectors have to give special attention to object lessons, and intuitive instruction is encouraged by providing rarer objects, and by offering a museum cabinet to any school in which a good commencement of a collection has been made.

As the Board is obliged to provide elementary instruction for *all* children, it has to furnish special instruction for a considerable number of deaf and dumb, and blind children. The deaf and dumb children are collected and taught at centres, of which there were a year ago thirteen. The number on the roll at these centres was 351, and the average attendance 286. The instruction was upon a combined articulation and finger alphabet system until July, 1877, when the oral system, which is now used, was adopted. Deaf and dumb children cannot be taught with speaking children, and, therefore, are kept in entirely separate classes and are not examined by the inspectors; but blind children usually attend the ordinary day-schools and share, as far as possible, the general instruction, receiving, however, on specified days, special instruction at centres, of which there were last year eighteen, and the total attendance at them was 132. Here the children are taught reading and writing by means of the "Braille" system and by the aid of Moon's type; written arithmetic by means of Taylor's arithmetic boards; and geography with relief maps and globes. Mental arithmetic receives special attention.

Manual Training.—An experiment of instructing boys in the use of tools was commenced in the Beethoven Street School, Queen's Park Estate, in September, 1885, the School-keeper of that school having been a carpenter by trade, and the boys were taught by him, under superintendence of the head master, two afternoons in the week.

The Annual Report of the School Board for 1888 states that an attempt is being made "to develop some regular system of working by which a boy can first draw, and then, from his own drawing, make a series of joints of increasing difficulty." Some articles have been made which are used in the board-schools, but the aim is "to give the boys the best possible course in practice, and to keep the question of utility in the background, only employing it to add a little zest or encouragement when the working of exercises seems likely to pall." This method of procedure is quite the opposite of the course pursued in the French schools, and it is the opinion of the writer that the French system is the best.

The Local Government Board would not approve of payments in connection with this experiment in manual training, and thereby prevented the opening of five additional classes which had been sanctioned by the School Board. Application was then made to the Education Department, requesting that manual training should be placed on the list of specific subjects under the code of the Department, but the reply was received that this could not be done until the question of technical education had been fully considered by Parliament. The School Board is still in hope that alterations in the code may be made that will allow manual training to be made a part of the ordinary school curriculum.

In May, 1887, the London School Board was requested by the City Guilds to appoint a deputation to consult with a number of their members, on a scheme for the equipment and maintenance, for one year, of four schools of elementary technical education, at a cost of about £1,000. The result was the establishment, by the Joint Committee, of six centres at which classes could be conducted, three north and three south of the Thames. The School Board could not legally render pecuniary aid to this object out of the

public funds, but it agreed to grant the necessary premises free of charge, and the expense of maintenance was undertaken by the City Guilds' Institute. The instructors had no specific directions as to the method of instruction, but were allowed to carry out their own ideas, subject to the broad line laid down under the following syllabus:

I—*Woods commonly used:*

(*a*) Conditions of growth.
(*b*) Felling and seasoning of timber.
(*c*) Properties of woods.
(*d*) Heartwood, sapwood, etc.
(*e*) Geographical distribution.

Museum of prepared specimens of woods to be formed in each centre.

II—*Tools:*

(1) Boy's set.
(*a*) Description.
(*b*) Manipulation.
(*c*) Sharpening.
(2) "Centre" set.
(*a b, c*) As above; less of detail.
(3) Nails and screws.
(*a*) Kinds.
(*b*) Uses.
(4) Two-foot rule.
To be specially treated.

III—*Practical work* (*A*):

Measuring and sawing to line.
Squaring piece of wood.
Nailing and screwing.
Simple joints.
(*a*) Exhibition of model of joint.
(*b*) Explanation of drawing of joint.
(*c*) Connection between model and drawing.
(*d*) Preparation of working drawings.

IV—*Practical work* (*B*):

(*a*) Construction of simple joints according to model and drawing.
(*b*) Construction of simple objects founded on simple joints.

V—*Practical work* (*C*):

(*a*) Gluing.
(*b*) Hinging.
(*c*) Knots, tying, etc.

Under the plan adopted, a class is conducted at a particular centre from 9 to 12 in the morning, once per week, and is attended by about thirty boys, drawn from the surrounding schools within a radius of about a mile. In the afternoon of the same day a second class is conducted, attended by another set of scholars; thus allowing for sixty boys to receive instruction at one centre during the day, on the north of the river, and sixty at another centre, south of the river, there being two instructors and two assistant instructors. During the five days of the week, the instructors take the various centres in rotation. Each boy is taken from his ordinary lessons only once per week, and the manual training lesson is made of a more satisfactory length than if the boy attended oftener for a shorter length of lesson each time.

The actual attendance at these schools is about ninety to ninety-six per cent. of the possible attendance. The workshops in each case consist of a single room, and are fitted with work-benches, varying in size according to the number of scholars which the room will accommodate, being generally each about 14 feet long and 2 feet wide. The benches are fitted with vises and other necessary attachments. It is intended to employ about thirty boys at a time, and the approximate arrangement is to have five benches with six vices each. This is different from the French practice, where smaller benches are used, and each boy has his own bench to himself—certainly a much better arrangement.

Each boy is provided with a set of tools, and in addition,

there are certain general tools for common use. Tool baskets, tool cupboards, sawing stools, etc., are also provided.

To assist in giving the pupils an intelligent idea of materials, two museums have been formed, one for the schools on the north side of the Thames, and the other for those on the south, consisting of suitable specimens of wood, properly labelled.

The cost of furnishing each centre is about £38 to £40, and the running expenses, including salaries, amount to about £370 per year, with an addition of £2 per month for timber.

Examinations are held in the autumn, and prizes are offered in competition.

The scheme worked very satisfactorily, and, on the recommendation of the committee, it was continued in 1889, the pecuniary aid being again furnished by the City Guilds. Owing to the success attending the manual training classes for boys as well as the cookery schools for girls, it was deemed advisable by the committee to extend the advantages of instruction in manual training for girls, and to this end several laundry classes were started, as an experiment, under the control of the Joint Committee. Five centres were established: two north and three south of the Thames. Instruction is given at each centre once per week, the hours being from 10 to 12 in the morning and from 2 to 4 in the afternoon, and the work is carried out in accordance with the following programme:

SCHOOL BOARD FOR LONDON.

Laundry Classes.

PROVISIONAL SYLLABUS.

I—*Work to be accomplished:*

(*a*) Washing of flannels, fine things, table linen, body and bed linen and prints.

(*b*) Folding, mangling, starching, ironing and glossing.

II—*Plan of carrying out the work:*

First Lesson.

(*a*) General idea of washing.
(*b*) Order of work to be done.
(*c*) Composition, action and use of soap, water, soda, blue, borax, and of alkalies and acids.
(*d*) Demonstration and practice.
  (1) Removing stains.
  (2) Disinfecting.

Second Lesson.

Washing flannels and Jaeger garments. Notes and practice.

Third Lesson.

Washing of fine things, viz: Laces, collars, pocket handkerchiefs, cuffs, etc. Notes and practice.

Fourth Lesson.

Washing of table linen, bed and body linen, prints, drying, folding and mangling.

Fifth Lesson.

Recipe for mixing cold starch; cleaning and heating of irons; management of fire; arrangement of iron table; ironing of collars and cuffs. Notes and practice.

Sixth Lesson.

Mixing of boiled starch; ironing the boiled starch things. Notes and practice.

Seventh Lesson.

Children, if possible, to bring small articles of their own to be washed, dried and folded by themselves.

Eighth Lesson.

Finishing of last week's practice by starching and ironing without aid, if possible. Glossing to be taught.

Ninth Lesson.

Written examination and practice lesson.

In the Autumn of 1887, a class was started for instruction in the "Slöjd" system of handicraft, and held on Sat-

urday mornings at the Medburn Street Board School, the course taking a period of three months. The class at first consisted of eighteen boys and two girls, but was afterward reduced to twelve, the number recommended for a class by Herr Saloman of Nääs. Some of the boys were very successful and reached such proficiency that they could go on without supervision, but others progressed very slowly. The girls worked equally well with the boys. The decision of the local Government Board that no expenses could be allowed on account of this instruction, obliged the discontinuance of the class, but it was afterward sanctioned for a further period of three months on a member of the Board agreeing to become responsible for the payment of the teacher's salary for that length of time.

There was a special committee appointed by the School Board of London in 1887 "to consider the present subjects and modes of instruction in the board-schools, and to report whether such changes can be made as shall secure that children leaving school shall be more fitted than they are now to perform the duties and work of life before them." This committee, after a full consideration of the whole subject for twelve months, including the taking of evidence from representatives of various classes of persons able to throw light upon the matter, made a report, in which were the following recommendations:

(1) That the methods of Kindergarten teaching in infants' schools be developed for senior scholars throughout the Standards in schools, so as to supply a graduated course of manual training in connection with science and object lessons, but not so as to include teaching the practice of any trade or industry; and that the method of Kindergarten in the senior schools be tried at first in a few special schools throughout London.

(2) That the teaching of all subjects be accompanied, where possible, by experiments and ocular demonstration, and that the School Management Committee be authorized to supply the necessary apparatus.

(3) That the Board encourage modelling in clay in all

departments of schools, both in connection with drawing as a training of the artistic faculties, and for the illustration of the teaching of geography and other subjects.

(4) That all manual instruction should be given in connection with the scientific principles underlying the work, and with suitable drawing and geometry.

(5) That, as soon as the Board are permitted by law to give special instruction in manual work, the School Management Committee bring up a scheme for giving such instruction.

(6) That classes for instruction in Slöjd be established in three selected schools approved by the School Management Committee.

(7) That the instruction in the classes for manual work and Slöjd be given only by such teachers as have qualified for that purpose.

(8) That as opportunity offers, accommodation shall be provided in connection with each boys', girls', and senior mixed department, in which instruction in manual and other practical work shall be given.

(9) Not important to present inquiry.

(10) That greater attention be paid to the teaching of mechanics as a specific subject, and that models for illustrating the instruction be placed on the requisition list.

(11) That instruction in practical geometry be included in the teaching of drawing, and that mechanical drawing to scale, with actual measurements, be encouraged in all boys' departments.

(12) That instruction in drawing be given in all girls' departments, though it be not necessarily taken as a subject of examination.

(13) That instruction in cookery be given only to girls over eleven years of age without regard to Standard, unless the express permission of the School Management Committee has been previously obtained, and that the necessary additional cookery centres be provided.

(14) That the time now given for dictation be reduced in all Standards, and that in substitution for the part omitted in the lower Standards, the reproduction by children

in their own words of passages read out to them, and in Standard IV and upwards, original composition, be usually taken.

(15) That the teaching of reading should be specially directed to give children an interest in books and to encourage them to read for their own pleasure, and that reading books should be used for imparting a knowledge of geography, history, social economy, and facts of common life to all children, who may not be able to take such subjects for examination.

(16) That, in order to allow time for experimental teaching and manual work, the time now given to spelling, parsing and grammar generally, be reduced.

(17) That the Board authorize the appointment of one or more additional instructors who shall give instruction on the peripatetic plan, in the science subjects authorized by the new code, as the necessity arises.

[*To be continued.*]

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated Meeting, held at the* INSTITUTE, *Tuesday, June 17, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, June 17, 1890.

Dr. H. F. Keller, Vice-President, in the Chair.

Members present—Dr. L. B. Hall, Dr. H. W. Jayne, Prof. R. L. Chase, Mr. G. L. Norris, Prof. E. F. Smith, Mr. Reuben Haines, Mr. A. A. Moore, Mr. H. Pemberton, Jr.

A letter from Dr. Wahl was received, announcing that indisposition prevented him from being present to read his paper illustrating the practical working of his process for the electro-deposition of platinum.

Prof. E. F. Smith read a valuable paper on the "Oxidation of Sulphur in Sulphides by Means of the Electric Current." The paper called forth some interesting comments from Drs. Hall and Keller and Mr. H. Pemberton, Jr. It was referred for publication in the JOURNAL OF THE INSTITUTE and in the *Berichte der deutschen chemischen Gesellschaft.*

Adjourned.

WM. C. DAY,
Secretary.

ON THE ELECTRO-DEPOSITION OF PLATINUM.

BY WM. H. WAHL.

[*Read at the Stated Meeting of the Chemical Section, May 20, 1890.*]

The permanence and unalterability of the metal platinum—properties which make it of such inestimable value to the chemist—have likewise suggested its application as a protective covering upon the surfaces of other metals; and, even in the early days of the art of electro-deposition, efforts to obtain a satisfactory coating of this metal were made. The failure with which these early experiments were attended, served rather to stimulate than to deter subsequent investigators, and the problem has received the attention of a number of the most noted experts in the art. The results that have been accomplished cannot be said to have been entirely satisfactory—a statement which, I believe, will be fully sustained by the fact that electro-plating with platinum, on the commercial scale, is practised only to a very limited extent. When the wide field of application for platinum-plating is considered—and I need only name philosophical, engineering, surgical, dental and electrical apparatus and instruments, fire-arms, watch-cases, and jewellery, to say nothing of the host of miscellaneous articles of utility and ornament to which the metal could be advantageously applied—the conclusion is warranted, that the processes thus far proposed for the purpose do not fully meet the requirements of practical service.

Thus far, of all the methods that have been proposed for electro-plating with platinum, three only appear to have sufficient merit to deserve special notice; these are:

(1) Roseleur-Lanaux' method, based on the electrolysis of a solution of the double phosphate of sodium and platinum.

(2) The process of the Bright Platinum Plating Company (of London), a modification of that of Roseleur, involving

the introduction into the bath of certain substances, such as sodium chloride and borax, to ensure a bright deposit of the metal; and

(3) Boettger's method, founded on the electrolysis of a solution of the double chloride of ammonium and platinum in sodium citrate.

Each of these baths will yield satisfactory results for a time: but, as I shall endeavor to show, the peculiar difficulties met with in the practice of platinum-plating render it impossible to maintain the chemical integrity of these electrolytes, and, in conseqence thereof, they soon become inefficient or inoperative by reason of contamination with the secondary products formed therein.

I will endeavor in what follows to give the true explanation of the difficulties above referred to, and to indicate what, from a careful study of the subject, fortified by the results of numerous experiments, I conceive to be the only feasible method of overcoming them.

The first difficulty encountered is that of obtaining a bright, reguline and adherent deposit of the metal, in which form only it will answer the demands of practice. There is no difficulty in effecting the separation of the metal from solutions of almost any of its compounds. Zinc, iron and tin reduce it promptly by simple immersion, and this very facility of reduction is one of the reasons why, even by the method of electrolysis, the desired object is frequently accomplished only in an imperfect manner; for the electroplater is obliged to meet and overcome its obstinate disposition to separate from many of its compounds in the condition of platinum black, lacking coherence and adherence, and therefore entirely unsuited for his purpose.

Another and no less serious difficulty arises from the insolubility of plates or sheets of this metal as anodes, when solutions containing platinum salts are submitted to electrolysis. In electro-plating with copper, silver, gold and nickel but little difficulty is encountered in practice on this account, since anodes of these metals are freely soluble in many solutions capable of depositing them when they are submitted to electrolysis, and the rate at which these anodes

are respectively dissolved, approximates so nearly to that at which the metals are deposited upon the objects at the cathode, that the metallic strength of the electrolyte is maintained substantially constant, and electro-plating solutions of these metals may be operated for a long time without requiring additions of metallic salts. The electro-deposition of the metals whose anodes are thus tractable is carried on industrially with success.

It results from this want of solubility of the anode that the metallic strength of the electrolyte employed is continuously being weakened, while the deposition of the metal is going on, and the conductivity of the bath is being continually modified thereby. The character of the deposited metal also is injuriously influenced by these constant alterations of condition in the bath; and, as the rate of deposition becomes slower and slower by reason of the gradual impoverishment of the metallic strength of the solution, it becomes necessary to restore it by fresh additions of metallic salt. The practice in all the processes of electro-plating with platinum employed up to the present time, save that of Boettger, is to use for this purpose the tetra-chloride of platinum. With this single exception, all the solutions for the electro-deposition of platinum thus far made known, so far as I am aware, are made by treating the chloride with compounds of the alkalies, soda, potassa, or ammonia. Of these, the phosphates and oxalates of soda, or potassa, are in greatest favor, and a number of formulæ for preparing platinum-plating baths with their aid have been described. The resulting substance is commonly a double salt, such, for example, as the double phosphate of sodium and platinum; the double oxalate of potassium and platinum, etc., contaminated, however, in each case by the chloride of the alkali employed, which is formed from the decomposition of the platinic chloride. As often as it is found necessary to strengthen the bath, fresh additions are made of platinic chloride, which, by chemical interaction with the constituents of the bath, aided by the process of electrolysis, yields more alkaline chloride; and it follows that the bath, by reason of becoming surcharged with this foreign substance,

and with other secondary products of electrolytic decomposition, ceases to yield bright, reguline platinum upon the articles to be plated therewith and must be discarded. It then becomes necessary to regain the platinum contained in the discarded bath, by one or another of several processes of reduction known to chemists. The platinum thus regained may be converted into chloride and utilized in the preparation of a fresh bath, with which the same series of operations may be repeated. Boettger purposes to maintain his bath by fresh additions of his original solutions, but it must be apparent that the continued electrolysis of such a solution as he employs must be attended with the constant accumulation therein of alkaline chlorides from the same causes as those specified above. This rapid deterioration of the baths, therefore, involves their frequent renewal at the expense of time and labor, so that, in spite of the fact that there is a wide field for its application, it is principally for this reason that the art of electro-plating with platinum on the commercial scale has thus far been practised only to a very limited extent.

It occurred to me that it might be practicable to overcome the principal difficulty here set forth. Knowing the influence of extent of surface in promoting the solubility of substances, it appeared to me at least probable that if the platinum were exhibited at the anode in the form of platinum-black, or sponge, exposing thus an enormously greater number of points of attack to the electro-negative element or acid radical there set free, the result might be the solution of the platinum, and the problem of maintaining the metallic strength of the electrolyte would thus be solved. The correctness of this conjecture was verified by experiment. For this purpose a plate of porous battery carbon, previously treated with boiling hydrochloric and nitric acids, was saturated repeatedly with a solution of platinic chloride and dried. It was then introduced into a graphite crucible, finely divided carbon was packed about it, and the crucible and contents heated for about half an hour to bright redness. The carbon plate then contained within its pores platinum in a state of eminently fine division. Treatment with water,

and with hydrochloric acid at boiling temperature, failed to leach out any platinum salt, showing that the previous treatment had sufficed to reduce all the platinum salt to the metallic state. The carbon plate was then suspended as the anode in moderately diluted hydrochloric acid, a platinum plate serving as the cathode. The acid bath was gently heated and a current of moderate strength was allowed to flow through it. There was a liberal evolution of hydrogen from the cathode, but little perceptible evolution from the anode. The acid solution gradually became colored from the formation of platinic chloride, and after some time the bright surface of the cathode began to blacken and ultimately became covered with a thick coating of platinum black. It was thus demonstrated that an anode of platinum in the state of fine division is readily soluble in an electrolyte which yields chlorine at the anode when the same is electrolyzed. This observation, so far as I am aware, is new. It proved, however, to have no practical value, since the solution of the anode demanded the presence of a large proportion of free acid in the plating-bath and the use of current of such strength as to produce invariably the deposition on the surfaces to be plated, of black and non-adherent metal. Furthermore, it was found as was to have been anticipated, that the physical condition of the anode exerted no influence whatever in the electrolysis of baths formed of the oxysalts of platinum, from which the best results in electro-plating are obtained—since, in electrolyzing such compounds, the acid radical separated upon the surface of the platinum black failed to exert any perceptible solvent action.

It was therefore necessary to devise some other plan for overcoming the difficulties herein described, and, after making a number of fruitless experiments, I was so fortunate as to find a plan which appears to offer a solution of the troublesome problem of electro-plating with the group of metals, whose anodes are insoluble, in a more satisfactory manner than any other that has hitherto been suggested.

The plan here referred to consists in employing platinum

hydroxide for the purpose of maintaining the metallic strength of the plating-bath. For this purpose, the hydroxide, which is readily soluble in alkalies and in many of the acids, may be introduced into the plating-bath from time to time and dissolved therein by stirring, or it may be permitted to remain in the bath in excess, the undissolved portion remaining at the bottom of the containing vessel, or it may be suspended in a canvas-bag adjacent to or surrounding the anode of carbon, according as the nature of the electrolyte may indicate one or the other method to be the preferable one. As the solutions which yield the best results in plating are those of the oxygen salts, I have found it advantageous also to prepare these directly from the hydroxide. This method, I have found, is capable of yielding a number of electrolytic baths of platinum that will maintain their metallic strength approximately unimpaired during electrolysis, and without the objectionable features of introducing into them substances that will cause them to deteriorate by the accumulation therein of injurious secondary products of decomposition, as is the case where such baths are maintained by additions of platinic chloride or alkaline chloroplatinates, as has hitherto been the invariable practice. Referring now specifically to the properties that render the platinic hydrate useful for the purposes above indicated, the following points appear to be deserving of mention.

It is readily soluble in aqueous solutions of the alkaline hydrates, and in a number of acids, mineral and vegetable. In the treatment of the platinic hydrate with aqueous solutions of the alkaline hydrates, the former plays the part of a weak acid forming compounds known as platinates, which are very soluble, and from which the platinum is not precipitated on the addition of an excess of alkali. A weak aqueous solution of sodic or potassic hydrate (but especially the last named) will dissolve a large quantity of platinic hydrate, at the ordinary temperature, though solution takes place more freely, when heat is applied. These solutions, have the advantageous features of being freely conductive of electricity, and of yielding bright, reguline, and adherent electro-deposits of platinum on metallic surfaces previously

prepared to accept the same. Furthermore, with a current of moderate strength, the platinic hydrate only is affected, as is shown by the pronounced evolution of oxygen at the anode and by the total absence of gas at the cathode. Also, it is manifest from the free solubility of platinic hydrate in alkaline hydrate, even in the cold, that if free platinic hydrate be present in a bath of alkaline platinate, the alkali set free in the process of electrolysis will combine with this platinic hydrate to form fresh platinate. For this purpose, it will be necessary either to have present in the bath at all times a small excess of platinic hydrate which may remain upon the bottom of the containing vessel, without interference with the plating, and which may be replenished from time to time; or, to introduce at the end of the day's work, a quantity of the platinic hydrate sufficient to restore the metallic strength of the bath to normal, assisting the solution of the metallic hydrate by stirring, and if necessary by the application of gentle heat. As I have found that the platinate solutions act best when they contain a considerable excess of free alkaline hydrate, being more conductive of the current and yielding the platinum more freely and in the best condition, the addition of the proper quantity of platinic hydrate at the close of the day's work in the case of a bath of considerable volume, or the addition of small quantities at intervals, in the case of a small bath, will be found to answer the desired purpose of maintaining the metallic strength of the bath approximately normal for an indefinite period. In a bath where considerable free alkali is present, the platinic hydrate added as just indicated, dissolves very freely even in the cold. The important fact is to be noticed, that the alkaline platinate solutions may be maintained and operated for a long time in the manner described, since no deleterious secondary products are formed by electrolysis to vitiate and render them inoperative, as will speedily be the case where the platinic chloride is used for this purpose. The mineral acids (hydrochloric, nitric, sulphuric, and phosphoric acids), dissolved the hydroxide freely, as likewise do certain of the vegetable acids, notably oxalic acid, and form with corresponding

salts of the alkalies, double salts, many of which are soluble in water. Of the salts thus capable of being formed, however, so far as I have been able to determine by experiment, only a limited number appear to be adapted to yield a deposit of bright, reguline and adherent platinum. The halogen compounds may obviously be prepared more conveniently by the direct solution of the metal in *aqua-regia* than by the method I have described, but as I have found the oxygen compounds of platinum to yield much more satisfactory results, I therefore exclude them from consideration.

Of the salts that may be formed from platinic hydrate by solution in acids (and in part by suitable combination with the corresponding alkaline compounds to form double salts), three only may be named as sufficiently useful to yield practically valuable results in plating. These are the phosphates, oxalates and acetates, of which also it is practicable to form double salts with the alkalies, soda, potassa and ammonia, which yield bright, reguline and adherent plating.

Oxalic acid, so far as I have been able to determine, is, of all the oxygen acids, the best solvent of platinic hydrate, dissolving it even in the cold, but with great energy when aided by heat, and forming platinous oxalate, with evolution of carbonic anhydride. From this brownish-black or deep blue solution (according to concentration), brilliant reddish-brown scales of the salt separate abundantly and readily from the hot saturated solution. A saturated aqueous solution of the simple oxalate prepared from the hydrate as above described, will yield bright, reguline, adherent platinum when electrolyzed with a comparatively weak current, with evolution of carbonic anhydride at the anode. With a stronger current hydrogen also appears at the cathode. This bath may be maintained indefinitely at normal metallic strength by observing the precaution to add oxalic acid and platinic hydrate in small quantities from time to time; or by keeping constantly at the bottom of the bath some platinic hydrate, and adding oxalic acid in crystals or powder from time to time as may be required

to keep the bath saturated; or, what is much to be preferred, making a supply of platinous oxalate from platinic hydrate in the manner previously described and keeping an excess of this present in the bath at all times. This bath has the same advantages as are possessed by the above-described alkaline platinate baths, of being capable of indefinite maintenance at normal metallic strength and of introducing no substances that will cause its deterioration by the formation of secondary decomposition products.

Phosphoric acid also is a solvent of platinic hydrate. A dilute aqueous solution of this acid will dissolve a small quantity of the metallic hydrate in the cold, and a much larger quantity when aided by heat. With increasing concentration, the solvent power of this acid for platinic hydrate is correspondingly increased. The resulting solution of phosphate of platinum according to the degree of concentration, will be wine-yellow to cherry-red in color, and with a comparatively weak current, will yield bright, reguline and adherent platinum on metallic surfaces properly prepared to accept the same. The electrolysis of this compound also, does not involve the formation of deleterious secondary products, the result of the operation being the separation of the metal at the cathode and of the acid radical at the anode—and of the elements of water which are evolved as gases respectively from anode and cathode. In the operation of the bath, therefore, it will become more and more acid as the metal is withdrawn by the accumulation therein of the phosphoric acid set free at the anode. The maintenance of the metallic strength of the bath, therefore, may be effected as in the foregoing cases by having present therein at all times a small quantity of platinic hydrate or by the addition at the end of each day's work of the quantity of the metallic hydrate which will be required to restore the amount of metal withdrawn. This bath must be worked very acid, and the solution of the platinic hydrate to maintain the strength of the bath must be facilitated by heating, as the solvent power of phosphoric acid for platinic hydrate is much inferior to that of oxalic acid. The double phosphates of platinum with cer-

tain of the alkalies may be formed, which will be capable of yielding a deposit of bright, reguline and adherent metal, and of being maintained approximately at normal metallic strength in the same manner as I have set forth above. I have obtained the best results with the ammonio-platinic phosphate, prepared by adding to the solution of platinic hydrate in phosphoric acid sufficient aqua ammoniæ to cause the same to give an alkaline reaction, which point will be indicated by the formation of a grayish precipitate that will not disappear on stirring; then restoring the acidity of the solution by adding free phosphoric acid in excess, upon which the precipitate readily dissolves. The resulting solution is yellowish or brownish, and yields superb plating; though, on account of the greater difficulty of maintaining its metallic strength by the solution of the hydroxide, it is not so well adapted as the oxalate for the work of electro-deposition on the large scale. The sodio-platinic phosphate, formed in a manner precisely analogous to the ammonia compound just described, will also yield bright, reguline and adherent plating; but I have observed that the soda salt is less freely soluble than the corresponding ammonia compound, and consequently more difficult than the latter to maintain of normal metallic strength.

Platinic hydrate is only very sparingly soluble in strong acetic acid, and it is impracticable to facilitate the solution by boiling, since by persisting in this for a very short time, the hydrate is decomposed and black platinic oxide is formed, which is quite insoluble in this menstruum. I have found, however, that an alkaline acetate bath may be prepared by the addition to the alkaline platinates above described, of as much acetic acid as may be introduced without causing the formation of a permanent precipitate. But although the appearance and quality of the plating obtained with this bath leave nothing to be desired, the bath does not meet the requirements in respect of indefinite maintenance in normal metallic strength and uniform composition. This difficulty, however, as I have observed, becomes less and less pronounced as the bath is made more strongly alkaline,

when it approximates more and more closely to the alkaline platinates; for it is obvious that in the presence of a large amount of free alkali, this would unite with the acetic acid to form a simple acetate. The resulting solution would no longer contain sodio- (potassio-) platinic acetate, but sodic (potassic) acetate, sodic (potassic) platinate, and free alkali. Nevertheless, the presence of acetic acid in such alkaline bath appears favorably to influence the quality of the plating yielded, giving the deposited metal a whiteness approaching that of silver; and since furthermore, acetic acid yields only the elements of water and volatile compounds, when electrolyzed and therefore does not contaminate the electrolytic bath by forming deleterious secondary products, I find its judicious addition to the above-described alkaline platinate baths to present some advantages.

The foregoing comprise the compounds that I have found to yield the most satisfactory results in platinum plating, and I will not tax your patience at this time by an enumeration of the results, either partially successful, or wholly unsuccessful, that I have obtained with a number of differently constituted compounds of this metal.

I append directions for the preparation of the several electrolytic baths above described, and indicate what I have found to be the most favorable conditions for working them.

In conclusion, I desire to make known the fact, which was brought to my knowledge only within the past week, that my friend, Prof. Wm. L. Dudley, of Vanderbilt University, Nashville, Tenn., has independently worked out the problem of electro-plating with iridium in a manner precisely analogous to that which I have herein described with platinum. Prof. Dudley has made no publication of his research, but in a letter, informs me that he employed, as long ago as 1886, the following procedure, which I quote, "a bath of the metal may be composed of either the chloride ($IrCl_4$), the double chloride of iridium and sodium, or a double sulphate of iridium-ammonium. The latter was preferred. The bath was kept saturated with metal by suspending canvas bags in the solution (either near to or around the anodes) containing the hydroxide of iridium."

DIRECTIONS FOR PREPARING THE ELECTRO-PLATING BATHS.—For the alkaline platinate bath, the following directions may suffice:

Platinic hydrate, ...	2 oz.
Caustic potassa (or soda).	8 oz.
Distilled water, ...	1 gallon.

Dissolve one-half of the caustic potassa in a quart of distilled water; add to this the platinic hydrate in small quantity at a time, facilitating solution by stirring with a glass rod. When solution is effected, stir in the other half of alkali dissolved in a quart of water; then dilute with a enough distilled water to form one gallon of solution. To hasten solution, the caustic alkali may be gently heated, but this is not necessary, as the platinic hydrate dissolves very freely. This solution should be worked with a current of about two volts and will yield metal of an almost silvery whiteness upon polished surfaces of copper and brass, and quite freely. There should be slight, if any, perceptible evolution of hydrogen at the cathode, but a liberal evolution of oxygen at the anode. I have observed that the addition of a small proportion of acetic acid to this bath improves its operation where a heavy deposit is desired. The anode may be of platinum or carbon, and owing to the readiness with which the metal is deposited an excess of anode surface is to be avoided. Articles of steel, nickel, tin, zinc, or German-silver, will be coated with black and more or less non-adherent platinum; but by giving objects of these metals a preliminary thin electro-deposit of copper in the hot cyanide bath, they may be electro-platinized in the alkaline platinate bath equally well as copper. The bath may be worked hot or cold, but it is recommended to work it at a temperature not exceeding 100° F. It may be diluted to one-half the strength indicated in the formula and still yield excellent results. The surface of the objects should be highly polished by buffing, or otherwise, prior to their introduction in the bath, if the resulting deposit is designed to be brilliant.

The deposition of platinum takes place promptly. In five minutes, a sufficiently heavy coating will be obtained for most

purposes. The deposited metal is so soft, however, that it requires to be buffed very lightly. A heavier deposit will appear gray in color, but will accept the characteristic lustre of platinum beneath the burnisher.

The oxalate solution is prepared by dissolving one ounce of platinic hydrate in four ounces of oxalic acid and diluting the solution to the volume of one gallon with distilled water. The solution should be kept acidified by the occasional addition of some oxalic acid. The simplest plan of using this bath, and which requires no attention to proportions, is simply to work with a saturated solution of the oxalate, keeping an undissolved excess always present at the bottom of the vessel. An addition of a small quantity of oxalic acid now and again will be found advantageous. The double salts of oxalic acid with platinum and the alkalies may be formed by saturating the bin-oxalate of the desired alkali, with platinic hydrate and maintaining the bath in normal metallic strength by the presence of an undissolved residuum of platinous oxalate.

The double oxalates are not so soluble in water as the simple salt. The oxalate baths, both of single and double salts, may be worked cold or hot (though not to exceed 150° F.), with a current of comparatively low pressure. The metal will deposit bright, reguline and adherent on copper and brass. Other metallic objects must receive a preliminary coppering as above. The deposited metal is dense, with a steely appearance, and can be obtained of any desired thickness.

The deposit obtained in the oxalate baths is sensibly harder than that from the alkaline platinate bath, and will bear buffing tolerably well.

The phosphate bath may be prepared by the following formula:

Phosphoric acid, syrupy (sp. gr. 1·7), ...	8 oz.
Platinic hydrate, ...	1–1½ oz.
Distilled water, ...	1 gallon.

The acid should be moderately diluted with distilled water, and the solution of the hydrate effected at the boiling temperature. Water should be added cautiously from

time to time to supply that lost by evaporation. When solution has taken place, the same should be diluted with sufficient water to make the volume one gallon. The solution may be worked cold or warm to 100° F., and with a current much stronger than that required for the platinates and oxalates. The ammonio- (and sodio)- platinic phosphates may be formed from the simple phosphate by carefully neutralizing the solution of the phosphate with ammonia (or soda); then adding an excess of phosphoric acid, or enough to dissolve the precipitate formed and an additional quantity to ensure a moderate amount of free phosphoric acid in the bath. The phosphate baths will be maintained of normal strength by additions of platinic hydrate, the solutions of which will have to be assisted by heating the bath, preferably at the close of each day's work. The metal yielded by the electrolysis of these phosphate solutions is brilliant and adherent. It has the same steely appearance as that exhibited by the oxalate solutions, but to a less pronounced degree. The physical properties of the deposited metal are in other respects like those described in connection with that obtained from the oxalate baths.

BOOK NOTICES.

THE CHRONICLE FIRE TABLES FOR 1890.—A record of fire losses in the United States by risks, States and causes during 1889, etc., and much other interesting and valuable information for fire underwriters. The Chronicle Company, Limited, New York. Royal 8vo, 300 pages. Price, $5.

This elaborate work, which is well denominated "an invaluable compilation of fire statistics," appears as the sixth volume of the enlarged series, showing aggregate property loss, during the year, of $123,046,833, of which $73,679,465 were the insurance losses. Fire underwriters, especially, but also many others, owe a debt of gratitude to the publishers for the carefully prepared and digested data which crowd 225 main pages and seventy-five pages of an appendix, as we shall prove by some examples. Besides the usual principal chart, giving number of fires among industrial works, warehouses, dwellings, theatres, public buildings, school-houses, railroad buildings, etc., burned during 1889, with property loss and insurance loss on the same and causes of fires as nearly as could be ascertained, pages 13 to 31 inclusive,

there are similar tabulations of fires, losses and causes *by States and Territories*, pages 32 to 139, and similar data *by causes*, pages 140 to 200.

The diagrams in this volume are especially valuable. In front, a colored one shows by red and yellow squares the *increase* of property loss, by fires through electric wires and lights, from $460,259 in 1886 to $5,533,820 in 1889! A series of diagrams covering pages 226 to 238, inclusive, shows graphically the proportions between fires of interior and exterior origin in all the numerous classifications. This is the great "exposure" risk, which plays such an important part in fire losses, and which must be studied, and as far as possible avoided (or else duly charged additional premium), by fire underwriters.

Other diagrams (3) show the movement of fire loss in the United States for fifteen years, the monthly curves of incendiary fires for seven years and the annual curves, since 1884, of fires and failures in the United States. The last is particularly suggestive. There are six other diagrams, showing, for the years 1884–1889, the geographical distribution, by States and Territories, of reported incendiarism. The changes indicated are well worthy of study, *e.g.*: In 1884, nine States had over 50 per cent. of their fires reported as incendiary, while in 1889 only three States showed so large a proportion.' In 1884, fifteen States had less than twenty per cent. reported incendiarism among fires, but in 1889 the number having this lowest percentage of incendiarism had risen to twenty-two: gratifying progress towards security, exhibited in dual form.

In the appendix are summaries of fires, losses and causes, by certain classes of risks, pages 239 to 297. We could give further illustrations of the excellent and concise mode in which the vast amount of fire data is arranged; but we have said enough, we think, to induce all connected with fire underwriting and the study of law and social economy, to purchase these tables, obtain the previous volumes, if they have them not, and register as subscribers for future issues. N.

BOOKS PURCHASED FOR THE LIBRARY. MAY–JUNE, 1890.

Bale, M. P. A Hand-Book for Steam Users.
Biddle, T. E. A Treatise on Model Yachts.
Bucknill, J. T. Submarine Mines.
Dana, J. D. Characteristics of Volcanoes.
Corals and Coral Islands.
Davies, D. C. A Treatise on Earthy and other Minerals.
Davies, G. C. Practical Boat Sailing.
Dunman, T. A Short Text-Book of Electricity and Magnetism.
Earl, A. G. Elements of Laboratory Work.
Encyclopædia of Monograms.
Grosvenor, J. duV. Model Yachts and Boats.

Hepworth, T. C. Photography for Amateurs.
Hough. The American Woods.
Kemp, D. A Manual of Yacht and Boat Sailing.
Liesegang, P. A Manual of the Carbon Process.
Neison, A. Practical Boat Sailing.
Pringle, A. Practical Photo-micrography.
Richards, J. W. Aluminium. (Second Edition.)
Scott, R. P. Cycling Art.
Speed, H. F. Cruises in Small Yachts.
Vaux, C. B. Canoe Handling.
Watt, A. Art of Leather Manufacture.
Art of Paper-making.
Art of Soap-making.
Wegmann, E. Masonry Dams.
Weisbach, P. J. Manual of Mechanics.
Wilkinson, W. T. Photo-engraving, Photo-etching, etc.
Winchell, A. Geological Excursions.
World-life.

June.

Bresson, M. L'Acier.
Church, A. H. The Chemistry of Paints and Painting.
Clarke, T. C., and others. The American Railway.
Congrès Internationale de Géologie. Premiere et deuxième Session.
Fleming, A. J. The Alternate Current Transformer.
Friedlaender, Dr. P. Fortschritte der Theerfarbenfabrikation.
Ganswindt, Dr. A. Handbuch der Färberei.
Gerhard, W. P. The Disposal of Household Wastes.
Glazebrook, R. T. and N. W. Shaw. Practical Physics.
Glazebrook, R. T. Physical Optics.
Gottgetreu, Rudolph. Physische und chemische Beschaffenheit der Baumaterialien.
Groth, P. Tabellarische Uebersicht der Mineralien.
Judd, J. W. Volcanoes.
Julius, Dr. Paul. Die künstlichen organischen Farbstoffe.
Kerl Bruno. Grundriss der Metallhüttenkunde.
Kohler, G. Lehrbuch der Bergbaukunde.
Langley, S. P. The New Astronomy.
Liebig's Annalen der Chemie, 153 Vols., 1832 to 1890.
Milne, J. Earthquakes.
Monie, H. The Cotton Fibre.
Rosenbusch, H. Mikroskopische Physiographie der Mineralien und Gesteine.
Rosenkranz, P. H. Der Indicator und seine Anwendung.
Sawyer, J. R. The A B C Guide to the making of Autotype Prints.
Serlo, Albert. Leitfaden zur Bergbaukunde.
Tiemann, F. und A. Gärtner. Die chemische und mikroskopisch-bakteriologische Untersuchung des Wassers.

Wagner's Jahresbericht über die Leistungen der chemischen Technologie, 1889.

Ware, W. R. Modern Perspective.

Weber, Martin. Das Schleifen, Polieren und Färben des Marmors.

GIFTS TO THE LIBRARY OF THE FRANKLIN INSTITUTE.

American Atlas. Historical, Chronological and Geographical. From Wm. C. Desmond.

American Machinist. Two copies. From Spencer Fullerton.

Baltimore. Sixty-first Annual Report of the Board of Commissioners of Public Schools. From the Board.

Beale, Lionel S. Disease Germs. From Dr. Isaac Norris, Jr.

Binghamton, N. Y., Water Commissioners' Annual Report. 1889. From the Commissioners.

Birkinbine, H. P. M. Pumping-Engines for the Water Supply. From Spencer Fullerton.

Boston Public Library. Bulletin No. 80. From the Library.

Bourne, John. Catechism of the Steam Engine. From Spencer Fullerton.

Brooklyn Library. Thirty-second Annual Report. From the Directors.

Bureau of Water, Philadelphia, Annual Report. 1888. From Spencer Fullerton.

Canadian Society of Civil Engineers. Charter, By-Laws, etc. From the Society.

Chronicle Fire Tables. 1890. From the Chronicle Company, Ltd.

Civil Service. Regulations and Improvements. From Spencer Fullerton.

Commercial Exchange. Philadelphia. Thirty-sixth Annual Report. From the Secretary.

Connecticut State Board of Health. Twelfth Annual Report. From the Board.

Dana, J. D. Manual of Mineralogy. From Spencer Fullerton.

Deutsch-Amerikanischen Techniker-Verbandes. Mittheilungen. May, 1890. From the Techniker Publishing Company.

Engineers' Society of Western Pennsylvania. Proceedings of April Meeting. From the Society.

Fisher's Mathematics Simplified. From Richard W. Gilpin.

Foulke, William Parker. Memoir. From Richard W. Gilpin.

Fox, L. Webster. A History of Spectacles. From the Author.

Geological Survey of India. Palæontologia Indica. Series 13, Vol. 4, Part 1. From the Survey.

Geological Survey of New Jersey. Annual Report of the State Geologist for 1889. From the Survey Office.

Germanischer Lloyd. Zweiter Nachtrag Internationales Register.
From L. Westergaard & Co.

Gilpin. Central Gold Region. From Richard W. Gilpin.

Grand Trunk Railway Company, of Canada. Report of the Directors. December 31, 1889. From the Company.

Guatemala. Informe de la Direccion General de Estadistica. 1889.
From the Director-General.

Hart, W. F. A Tabular Statement of the Principal Provisions in the Patent Laws. From the Author.

Harvard College Observatory Annals. Vol. 18, No. 10.
Henry Draper Memorial. Fourth Report.
From the Director of the Observatory.

Historical Sketch of the Invention of Vertical Tubular Boilers.
From Spencer Fullerton.

Houpt, J. Improvements in Steam Engines. From Spencer Fullerton.

Insurance Company of North America. A History.
From Spencer Fullerton.

Interstate Fair Association, New Jersey. List of Prizes.
From the Association.

Johns Hopkins University Register. 1889–90. From the University.

Kennedy, J. H. The Three Witnesses of the Book of Mormon.
From Secretary, Oneida Historical Society.

King, W. H. Practical Notes on the Steam Engine.
From Spencer Fullerton.

Lombard Investment Company. Annual Report.
From Spencer Fullerton.

Louisiana Board of Health. Biennial Report. 1888–89.
From the Board.

Massachusetts State Agricultural Experiment Station. Analyses of Commercial Fertilizers. May and June, 1890. From the Station.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, June 18, 1890.*]

Hall of the Franklin Institute,
Philadelphia, June 18, 1890.

Chas. Bullock, Vice-President, in the Chair.

Present, forty-one members and eight visitors.

Additions to membership since previous meeting, thirteen.

Mr. S. Lloyd Wiegand (in place of Mr. Francis LeClere, absent on account of illness) gave a description of an improved spindle support devised by Messrs. Bates, Shaw & Von Culin. Mr. Wiegand illustrated the subject

with the aid of a very complete exhibit of various forms of these devices, ancient and modern, and with several views of spinning frames.

Mr. W. N. JENNINGS exhibited on the screen and described a series of remarkable photographs of lightning flashes, which he had succeeded in obtaining in the neighborhood of Germantown during the violent thunder-storm of June 11th. One of these exhibited the appearance of a number of *black* branches radiating from the bright main stem of the flash. This singular phenomenon evoked considerable speculation as to its cause, and opinions thereon were ventured by Messrs. WIEGAND, SARTAIN, IVES and JENNINGS.

The Secretary presented an elaborate account of the present state of the art of electric welding, as represented by the Thomson Electric Welding Company's operations. He referred, among other things, to the fact that the system had already passed the experimental stage, and gave an account of the various uses to which it had already been successfully applied. He referred to, and quoted from, special reports that had been made on the system by Mr. Alex. B. W. Kennedy, F.R.S.; Prof. Silvanus P. Thompson, F.R.A.S., and the United States Naval Board, appointed by the Secretary of the Navy. The Secretary's remarks were illustrated with the aid of lantern pictures, showing several forms of the welders used in service.

Mr. F. L. GARRISON, seconded by Mr. WIEGAND, offered the following:

WHEREAS, It is the purpose of the British Iron and Steel Institute and the German Society of Iron Masters, to visit this city in a body during October next, with the object of viewing our industries and institutions; and,

WHEREAS, It is the policy and pleasure of this INSTITUTE to extend its privileges to the representatives of such distinguished foreign institutions;

Therefore, RESOLVED, That the FRANKLIN INSTITUTE hereby extends the use of its Hall and the privileges of its library to the visitors during their stay in the city.

Adopted unanimously.

Mr. W. E. LOCKWOOD laid before the meeting copies of pending bills before Congress, appropriating $25,000 for the purpose of determining the amount of the so-called hammer-blow of a locomotive driving-wheels; also, for appropriating $500,000 for the erection of an additional fire-proof building for the National Museum.

Dr. ISAAC NORRIS, on behalf of Mr. Gutekunst, presented a neatly-framed photograph of the late GEORGE S. PEPPER.

Adjourned. WM. H. WAHL, *Secretary.*

PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW
FOR MAY, 1890.

Prepared under the Direction of the Committee on Meteorology of the
FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 31, 1890.

TEMPERATURE.

The mean temperature of 59 stations for May, 1890, was 58°·8, which is about 1° below the normal.

The mean of the daily maximum and minimum temperatures 69°·6 and 47°·4 give an average daily range of 22°·2, and a monthly mean of 58°·5.

Highest monthly mean, 63°·9 at Annville.

Lowest monthly mean, 52°·5 at Eagles Mere.

Highest temperature recorded during the month, 89° on 31st, at Wilkes-Barre.

Lowest temperature, 23° on the 1st at Nisbet.

Greatest local monthly range, 31°·7 at Selins Grove.

Least local monthly range, 15° at Eagles Mere.

Greatest daily range, 48° at Lewistown on 13th.

Least daily range, 1° at Le Roy on 30th.

From January 1, 1890 to May 31, 1890, the excess in temperature at Philadelphia was 650°, and at Erie 383°.

BAROMETER.

The mean pressure for the month, 29·96, is about normal. At the U. S. Signal Service Stations, the highest observed was 30·31 at Philadelphia on the 22d and the lowest 29·60 at Harrisburg on the 5th.

PRECIPITATION.

The average precipitation, 6·71 inches, is an excess of three and one-half inches. Rains were of almost daily occurrence in some parts of the state. The 17th, 28th and 29th were the only days on which no rain was reported The largest monthly totals in inches were: Girardville, 12·41; Emporium, 9·61; Eagles Mere, 8·97; Somerset, 8·90; Mauch Chunk, 8·11; Gettysburg, 8·10, and Uniontown, 8·03. The least was Philadelphia, 2·96.

WIND AND WEATHER.

The prevailing wind was from the west. On the 10th, about 5 P.M., a tornado passed over the southern part of Franklin County, doing considerable damage. The weather during the month was excessively wet. The ground was saturated and cold, and caused much delay in plowing and seeding. Average number: Rainy days, 15; clear days, 7; fair days, 11 cloudy days, 13.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Gettysburg, 13th, 14th, 19th; Charlesville, 1st, 3d, 5th, 23d, 30th; Blue Knob, 5th, 10th, 11th, 13th, 19th, 20th, 23d, 24th, 25th, 26th; Hollidaysburg, 13th, 14th, 19th, 23th, 25th, 30th; Tipton, 10th, 13th, 14th, 18th, 23d, 25th, 30th; Le Roy, 13th, 14th; Forks of Neshaminy, 13th, 14th; Quakertown, 1st, 4th, 13th, 14th, 20th; Johnstown, 13th, 14th, 18th, 23d, 24th, 25th; Emporium, 3d, 10th, 13th; Mauch Chunk, 13th, 14th, 19th, 20th; State College, 5th, 13th, 14th, 18th, 23d, 30th; Phillipsburg, 23d; West Chester, 1st, 13th, 14th; Coatesville, 1st, 4th, 13th, 14th, 20th; Westtown, 13th, 16th, 19th; Rimersburg, 10th, 18th, 23d, 24th, 25th; Clarion, 3d, 4th, 9th, 24th, 25th, 30th; Lock Haven, 5th, 13th, 14th, 25th; Catawissa, 14th, 19th; Meadville, 3d, 5th, 10th, 13th, 18th, 22d, 23d, 24th, 25th, 30th; Carlisle, 1st, 13th, 19th, 25th; Harrisburg, 14th, 19th, 25th; Swarthmore, 2d, 13th, 14th, 16th; Uniontown, 10th, 13th, 18th, 23d, 24th, 30th; Chambersburg, 1st, 19th, 30th; Huntingdon, 13th, 14th, 19th, 23d, 26th, 30th; Petersburg, 5th, 13th, 23d; Lancaster, 1st, 13th, 14th, 19th, 25th; Myerstown, 1st, 13th, 14th, 19th, 20th, 26th; Annville, 1st, 13th, 14th, 18th, 19th, 20th, 23d, 25th, 26th; Scranton, 14th, 19th, 20th; Wilkes-Barre, 13th, 14th, 19th; Lewistown, 1st, 13th, 14th, 18th, 23d, 30th; Philadelphia, 1st, 13th, 14th, 16th; Girardville, 4th, 14th, 19th; Selins Grove, 5th, 14th, 15th, 18th, 19th; Somerset, 11th, 15th, 24th, 26th, 27th; Wellsboro, 5th, 10th, 12th, 25th; Lewisburg, 6th, 13th, 14th, 18th, 19th; Columbus, 3d, 10th, 18th, 25th; Dyberry, 13th, 14th, 19th; Ligonier, 23d; South Eaton, 14th, 19th, 20th; York, 13th, 23d.

Hail.—Gettysburg, 1st, 19th; Charlesville, 25th; Blue Knob, 30th; Hollidaysburg, 13th; Tipton, 23d; Quakertown, 24th; Mauch Chunk, 19th; Coatesville, 1st; Petersburg, 13th; Lewistown, 13th; Philadelphia, 1st; Somerset, 24th; Lewisburg, 14th; York, 2d.

Snow.—Blue Knob, 7th.

Frost.—Gettysburg, 12th, 17th; Charlesville, 17th; Blue Knob, 2d, 7th, 8th, 16th, 18th, 21st; Hollidaysburg, 2d; Tipton, 2d, 7th, 12th, 17th, 18th, 28th; Le Roy, 2d, 8th, 12th, 18th, 21st; Quakertown, 2d, 7th, 9th, 17th; Emporium, 2d, 12th, 18th; State College, 2d, 18th; Phillipsburg, 2d; West Chester, 9th; Coatesville, 9th; Rimersburg, 2d, 8th, 18th, 21st; Grampian Hills, 2d, 7th; Lock Haven, 7th, 12th; Catawissa, 2d, 7th, 12th; Meadville, 2d, 7th, 8th, 18th, 21st, 28th; Carlisle, 7th, 12th, 17th; Uniontown, 2d, 8th, 13th, 18th; Huntingdon, 7th, 12th; Petersburg, 2d, 7th, 12th; Myerstown, 2d, 17th; Wilkes-Barre, 2d, 7th; Nisbet, 1st, 7th, 12th, 17th, 18th, 28th; Lewistown, 2d; Philadelphia, 9th; Girardville, 2d, 9th, 17th, 18th; Selins Grove, 2d, 8th, 12th, 28th; Somerset, 13th, 18th, 19th, 29th; Eagles Mere, 2d, 7th; Wellsboro, 2d, 3d, 7th, 8th, 9th, 11th, 21st, 28th; Lewisburg, 7th, 12th; Columbus, 2d, 7th, 8th, 12th, 18th; Dyberry, 2d, 3d, 7th, 9th 12th, 17th, 18th; Honesdale, 2d, 3d, 9th, 12th; South Eaton, 2d, 9th; York, 7th, 9th.

Sleet.—Wellsboro, 20th.

Coronæ.—Charlesville, 30; Annville, 29th; Lewistown, 2d, 24th; Dyberry, 28th.

Solar Halos.—Le Roy, 2d, 3d, 9th, 21st; Meadville, 16th; Eagles Mere, 9th; Wellsboro, 9th, 18th, 29th; Dyberry, 3d, 8th, 9th, 27th.

Cou	Precipitation. Total Inches.	Number of Days Rainfall.	Number of Days. Clear.	Fair.	Cloudy.	Wind. Prevailing Direction. 7 A. M.	2 P. M.	9 P. M.	Observers.
Adams,[1]	8·10	15	6	7	18	S	S	S	Prof. E. S. Breidenbaugh.
Allegheny,	5·85	20	6	8	17	SW	SW	SW	Oscar D. Stewart, Sgt. Sig. Corps.
Bedford,	5·65	16	5	13	13	SW	SW	SW	Miss E. A. G. Apple.
Berks,[1]	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	C. M. Dechant, C.E.
Blair,[2]	4·47	14	. . .	. . .	. . .	. . .	. . .	. . .	Dr. Charles B. Dudley.
Blair,	6·70	18	6	12	13	NW	NW	NW	A. H. Boyle.
Blair,	5·82	18	8	9	14	SW	W	W	Prof. J. A. Stewart.
Blair,	5·03	16	9	9	13	W	W	W	Miss Cora J. Wilson.
Bradford,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Charles Beecher.
Bradford,	7·00	15	7	10	14	SW	SW	SW	Geo. W. T. Warburton.
Bucks,	5·00	10	10	12	8	NW	NW	W	J. C. Hilsman.
Bucks,	6·55	12	8	10	13	SW	SW	S	J. L. Heacock.
Bucks,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Lewis P. Townsend.
Cambria,[1]	6·90	23	7	9	15	SE	SE	SE	E. C. Lorentz.
Cameron,	9·61	14	9	8	14	W	W	W	T. B. Lloyd.
Carbon,[1]	8·11	16	10	12	9	NW	NW	NW	John J. Boyd.
Centre,	6·77	18	4	11	16	W	W	W	Prof. Wm. Frear.
Centre,	7·02	15	. . .	. . .	. . .	SW	SW	SW	Geo. H. Dunkle.
Chester,	6·42	18	12	13	6	E	S	SE	Jesse C. Green, D.D.S.
Chester,	7·85	14	10	11	10	W	S	S	W. T. Gordon.
Chester,[1]	6·89	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Benj. P. Kirk.
Chester,	5·90	14	8	13	10	W	W	NW	Prof. Wm. F. Wickersham.
Clarion,	. . .	. . .	6	13	12	W	W	SW	Rev. W. W. Deatrick, A.M.
Clarion,	7·20	. . .	. . .	. . .	. . .	SW	SW	SW	C. M. Thomas, B.S.
Clearfield,	6·87	19	2	11	18	W	SW	SW	Nathan Moore.
Clinton,	7·30	17	6	13	12	W	W	W	Prof. John A. Robb.
Columbia,	7·41	10	. . .	. . .	. . .	. . .	. . .	. . .	Robert M. Graham.
Crawford,	7·04	17	5	17	9	S	S	S	J. & B. H. Metcalf.
Cumberlan	5·47	16	3	15	13	S	S	S	J. E. Pague.
Dauphin,[1]	6·61	17	6	13	12	E	E	E	Frank Ridgway, Sgt. Sig. Corps.
Delaware,	5·59	13	3	9	19	N	SW	N	Prof. Susan J. Cunningham.
Erie,[1]	6·40	20	5	9	17	W	W	W	Peter Wood, Sgt. Sig. Corps.
Fayette,	8·03	17	8	17	6	. . .	. . .	. . .	Wm. Hunt.
Forrest,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	R. L. Haslet.
Franklin,[1]	5·55	17	9	7	15	. . .	. . .	. . .	Miss Mary A. Ricker.
Fulton,	7·90	16	9	12	10	W	NW	W	Thomas F. Sloan.
Greene,	4·90	14	10	9	12	. . .	. . .	. . .	Capt. W. C. Kimber.
Huntingdo	6·36	14	5	12	14	W	W	W	Prof. W. J. Swigart.
Huntingdo	6·95	16	7	10	14	W	W	W	J. E. Rooney.
Indiana,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Prof. S C. Schmucker.
Lackawan	4·77	16	3	7	21	S	S	S	C. A. Hinsdell.
Lancaster,	7·04	12	9	12	10	NW	W	W	C. N. Heller.
Lawrence,	7·25	14	8	10	13	W	W	W	Wm. T. Butz.
Lebanon,	6·79	13	5	8	18	W	W	W	Wm. H. Kline.
Lebanon,	. . .	. . .	4	12	15	W	W	W	Geo. W. Bowman, A.M., Ph.D.
Lehigh,	7·93	12	7	15	9	SE	SW	SE	M. H. Boye.
Lehigh,[1]	5·00	. . .	6	12	13	. . .	. . .	. . .	John C. Wuchter.
Luzerne,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	H. D. Miller, M.D.
Luzerne,[1]	6·84	13	11	4	16	NE	. . .	N	A. W. Betterly.
Lycoming,	6·20	11	9	11	11	W	. . .	E	John S. Gibson, P. M.
Mercer,[1]	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Prof. S. H. Miller.
Mifflin,	6·88	16	8	13	10	NW	NW	NW	Culbertson & Lantz.
Montgome	7·61	10	15	8	8	W	W	W	Charles Moore, D.D.S.
Northampt	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Lerch & Rice.
Perry,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Frank Mortimer.
Philadelph	2·96	16	7	13	11	SE	SE	SE	Luther M. Dey, Sgt. Sig. Corps.
Potter,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	C. L. Peck.
Schuylkill,	12·41	16	15	7	9	NW	NW	W	E. C. Wagner.
Snyder,	3·56	12	10	15	6	SE	SE	SE	J. M. Boyer,
Somerset,	8·90	14	2	14	15	NW	NW	NW	W. M. Schrock.
Sullivan,	8·97	13	6	12	13	SW	SW	SW	E. S. Chase.
Tioga,	7·80	20	4	13	14	N	S	N	H. D. Deming.
Union,[1]	6·40	13	1	19	11	SW	SW	SW	F. O. Whitman.
Warren,	9·15	20	6	10	15	SW	SW	SW	Wm. Loveland.
Washingt	5·20	23	. . .	. . .	. . .	. . .	. . .	. . .	A. L. Runion, M.D.
Wayne,	5·56	12	5	12	14	NW	NW	NW	Theodore Day.
Wayne,	6·11	12	. . .	. . .	. . .	. . .	. . .	. . .	John Torrey.
Westmore	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Hilary S. Brunot.
Westmore	6·79	20	. . .	. . .	. . .	. . .	. . .	. . .	J. T. Ambrose.
Wyoming,	7·47	15	7	10	14	S	S	S	Benj. M. Hall.
York,[1]	6·65	11	15	8	8	NW	. . .	SW	Mrs. L. H. Grenewald.

T. F. TOWNSEND, *Sergeant Signal Corps*, As

Germantown.	Point Pleasant.	Bethlehem.	Canonsburg.	Carlisle.	Centre Valley.	McConnellsburg.	Waynesburg.	Lewisburg.	Mauch Chunk.	Nisbet.	Charlesville.	Lynnport.	Tionesta.	Gettysburg.	Lewistown.	Greensburg.	Tipton.	Coudersport.	Coopersburg.	Hulmeville.	Westtown.	Meadville.	Ligonier.	Scranton.
·87	·13	. .	. .	. .	. .	. .	·30	·36	·09	·20	·01	. .	. .	·42	·08	. .	·20	. .	·12	. .	·28	·19	·26	·20
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·07	·28	. .	. .	·02	. .	·35	·30	·60	·43	. .	·66	. .	. .	·47	·42	. .	·09	. .	·89	. .	. .	·60	·61	·20
. .	·21	. .	. .	·88	. .	·65	. .	. .	·49	·80	·02	. .	. .	·43	·42	. .	·05	. .	·91	. .	. .	·56	·12	·24
·90	·53	. .	. .	·78	. .	1·40	·50	1·20	·29	·90	·41	. .	. .	·55	·44	. .	·55	. .	·47	. .	·70	. .	·37	·43
. .	. .	. .	. .	·01	. .	·09	. .	. .	·01	. .	·11	. .	. .	·20	·03	. .	. .	. .	. .	. .	. .	. .	·06	. .
·42	·37	. .	. .	. .	. .	·04	. .	. .	. .	·20	. .	. .	. .	. .	. .	. .	. .	. .	·17	. .	·50	. .	. .	. .
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. .	·01	. .	. .	·03	. .	·04	·45	·46	·02	·30	·04	. .	. .	·40	·06	. .	·05	. .	. .	. .	·05	1·31	·20	·08
·05	. .	. .	. .	. .	. .	. .	. .	. .	·23	. .	. .	. .	. .	. .	·55	. .	·05	. .	·04	. .	. .	. .	·33	·20
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·73	. .	. .	. .	. .	. .	·34	·35	·50	·48	·50	·56	. .	. .	·40	1·22	. .	·10	. .	. .	. .	. .	·22	·21	·02
. .	. .	. .	. .	·31	. .	·20	·50	·99	·80	·70	·07	. .	. .	·29	·31	. .	·23	. .	2·18	. .	·95	·21	·47	·75
·50	1·01	. .	. .	·26	. .	. .	. .	. .	·10	. .	·01	. .	. .	·72	. .	. .	. .	. .	·26	. .	. .	. .	. .	·02
·22	. .	. .	. .	. .	. .	. .	. .	·01	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·83	·04	·01	·01
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. .	. .	. .	. .	·10	. .	·84	·20	·31	1·07	·30	·87	. .	. .	1·86	·28	. .	·11	. .	. .	. .	. .	·56	·15	·40
·06	·80	. .	. .	1·46	. .	·90	·50	·80	1·41	·80	·62	. .	. .	·82	·59	. .	·40	. .	·50	. .	·82	·72	·80	1·18
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·03	. .	. .	. .	·05	. .	. .	·20	·02	. .	. .	. .	. .	. .	. .	·04	. .	. .	. .	. .	. .	. .	·03	·05	. .
. .	. .	. .	. .	·06	. .	. .	·30	·53	·04	·80	·77	. .	. .	·37	·68	. .	1·40	. .	. .	. .	. .	1·77	1·52	·01
. .	. .	. .	. .	·19	. .	·72	·45	. .	. .	. .	. .	. .	. .	·01	. .	. .	. .	. .	. .	. .	. .	·04	·13	. .
. .	. .	. .	. .	. .	. .	1·10	·20	. .	. .	. .	1·24	. .	. .	·01	·63	. .	·93	. .	. .	. .	. .	·21	1·00	. .
·05	. .	. .	. .	1·00	. .	·80	·35	. .	1·95	·70	·17	. .	. .	1·15	1·04	. .	·60	. .	2·03	. .	1·76	. .	·01	·47
·55	2·21	. .	. .	·20	. .	·15	. .	·61	·60	. .	. .	. .	. .	. .	. .	. .	. .	. .	·32	. .	. .	. .	. .	·52
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·05	·02	. .	. .	. .	. .	·15	. .	·01	·10	. .	. .	. .	. .	. .	. .	. .	·12	. .	·04	. .	·01	. .	·01	·04
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50	5·57	. .	5·20	5·47	. .	7·90	4·90	6·40	8·11	6·20	5·65	5·00	. .	8·10	6·88	. .	5·03	. .	7·93	. .	5·90	7·04	6·79	4·77

T. F. T.

Germantown.	Point Pleasant.	Bethlehem.	Canonsburg.	Carlisle.	Centre Valley.	McConnellsburg.	Waynesburg.	Lewisburg.	Mauch Chunk.	Nisbet.	Charlesville.	Lynnport.	Tionesta.	Gettysburg.	Lewistown.	Greensburg.	Tipton.	Coudersport.	Coopersburg.	Hulmeville.	Westtown.	Meadville.	Ligonier.	Scranton.
·87	·13	. .	. .	. .	. .	. .	·30	·36	·09	·20	·01	. .	. .	·42	·08	. .	·20	. .	·12	. .	·28	·19	·26	·20
. .	. .	. .	. .	·10	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
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·07	·28	. .	. .	·02	. .	·35	·30	·60	·43	. .	·66	. .	. .	·47	·42	. .	·09	. .	·89	. .	. .	·60	·61	·20
. .	·21	. .	. .	·88	. .	·65	. .	. .	·49	·80	·02	. .	. .	·43	·42	. .	·05	. .	·91	. .	. .	·56	·12	·24
·90	·53	. .	. .	·78	. .	1·40	·50	1·20	·29	·90	·41	. .	. .	·55	·44	. .	·55	. .	·47	. .	·70	. .	·37	·43
. .	. .	. .	. .	·01	. .	·09	. .	. .	·01	. .	·11	. .	. .	·20	·03	. .	. .	. .	. .	. .	. .	. .	·06	. .
·42	·37	. .	. .	. .	. .	·04	. .	. .	. .	·20	. .	. .	. .	. .	. .	. .	. .	. .	·17	. .	·50	. .	. .	. .
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. .	·01	. .	. .	·03	. .	·04	·45	·46	·02	·30	·04	. .	. .	·40	·06	. .	·05	. .	. .	. .	·05	1·31	·20	·08
·05	. .	. .	. .	. .	. .	. .	. .	. .	·23	. .	. .	. .	. .	. .	·55	. .	·05	. .	·04	. .	. .	. .	·33	·2[illegible]
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·73	. .	. .	. .	. .	. .	·34	·35	·50	·48	·50	·56	. .	. .	·40	1·22	. .	·10	. .	. .	. .	. .	·22	·21	·02
. .	. .	. .	. .	·31	. .	·20	·50	·99	·80	·70	·07	. .	. .	·29	·31	. .	·23	. .	2·18	. .	·95	·21	·47	·75
·50	1·01	. .	. .	·26	. .	. .	. .	. .	·10	. .	·01	. .	. .	·72	. .	. .	. .	. .	·26	. .	. .	. .	. .	·[illegible]2
1·22	. .	. .	. .	. .	. .	. .	. .	·01	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·83	·04	·01	·01
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. .	. .	. .	. .	·10	. .	·84	·20	·31	1·07	·30	·87	. .	. .	1·86	·28	. .	·11	. .	. .	. .	. .	·56	·15	·40
·06	·80	. .	. .	1·46	. .	·90	·50	·80	1·41	·80	·62	. .	. .	·82	·59	. .	·40	. .	·50	. .	·82	·72	·80	1·18
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·03	. .	. .	. .	·05	. .	. .	·20	·02	. .	. .	. .	. .	. .	. .	·04	. .	. .	. .	. .	. .	. .	·03	·05	. .
. .	. .	. .	. .	·06	. .	. .	·30	·53	·04	·80	·77	. .	. .	·37	·68	. .	1·40	. .	. .	. .	. .	1·77	1·52	·01
. .	. .	. .	. .	·19	. .	·72	·45	. .	. .	. .	. .	. .	. .	·01	. .	. .	. .	. .	. .	. .	. .	·04	·13	. .
. .	. .	. .	. .	. .	. .	1·10	·20	. .	. .	. .	1·24	. .	. .	·01	·63	. .	·93	. .	. .	. .	. .	·21	1·00	. .
1·05	. .	. .	. .	1·00	. .	·80	·35	. .	1·95	·70	·17	. .	. .	1·15	1·04	. .	·60	. .	2·03	. .	1·76	. .	·01	·47
·55	2·21	. .	. .	·20	. .	·15	. .	·61	·60	. .	. .	. .	. .	. .	. .	. .	. .	. .	·32	. .	. .	. .	. .	·52
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·05	·02	. .	. .	. .	. .	·15	. .	·01	·10	. .	. .	. .	. .	. .	. .	. .	·12	. .	·04	. .	·01	. .	·01	·04
. .	. .	. .	. .	·02	. .	. .	·30	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·39	. .
5·50	5·57	. .	5·20	5·47	. .	7·90	4·90	6·40	8·11	6·20	5·65	5·00	. .	8·10	6·88	. .	5·03	. .	7·93	. .	5·90	7·04	6·79	4·77

T. F. T.

Lunar Halos.—Meadville, 29th; Huntingdon, 28th; Lancaster, 24th, 31st; Lewistown, 1st; Somerset, 27th; Dyberry, 5th.

Parhelias.—Le Roy, 8th, 30th; Annville, 30th.

Zodiacal Lights.—Charlesville, 27th; Le Roy, 2d.

Mirage.—Harrisburg, 11th.

WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for May, 1890:

Weather, 83 per cent.
Temperature, 89 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
C. W. Burkhart,	Shoemakersville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
Capt. A. Goldsmith,	Quakertown.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
New Era,	Lancaster.
State Normal School,	Clarion.
Clarion Collegiate Institute,	Rimersburg.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
J. E. Forsythe,	Butler.
James H. Fones,	Tionesta.
Steward M. Dreher,	Stroudsburg.

Displayman.	*Station.*
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
Hartford P. Brown,	Rochester.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. M. Wildman,	Langhorne.
G. W. Klee,	Chambersburg.
A. Simon's Sons,	Lock Haven.
Raftsman's Journal,	Clearfield.
W. S. Ravenscroft,	Hyndman.
R. C. Schmidt & Co.,	Belle Vernon.
Chas. B. Lutz,	Bloomsburg.
E. C. Lorentz,	Johnstown.
W. M. James,	Ashland.
Miller & Allison,	Punxsutawney.
Dr. A. L. Runion,	Canonsburg.
E. J. Sellers,	Kutztown.
C. A. Hinsdell,	Scranton.
H. J. Fosnot,	Lewistown.
H. M. Kaisinger,	Hartsville.
E. Jennet,	Franklin.
Milton C. Cooper,	Ashbourne.
Geo. W. Bowman,	Annville.
P. S. Weber,	DuBois.
Foulk & Co.,	Milford.
William Lawton,	Wilmington, Del.
Wister Heberton & Co.,	Germantown.
Charles M. Mullen,	Bedford.
E. W. Merrill,	North East.
A. Simon's Sons,	Lock Haven.
Frank Ridgway,	Harrisburg.
G. W. Yost,	Collegeville.
A. C. Tryon,	Spartansburg.

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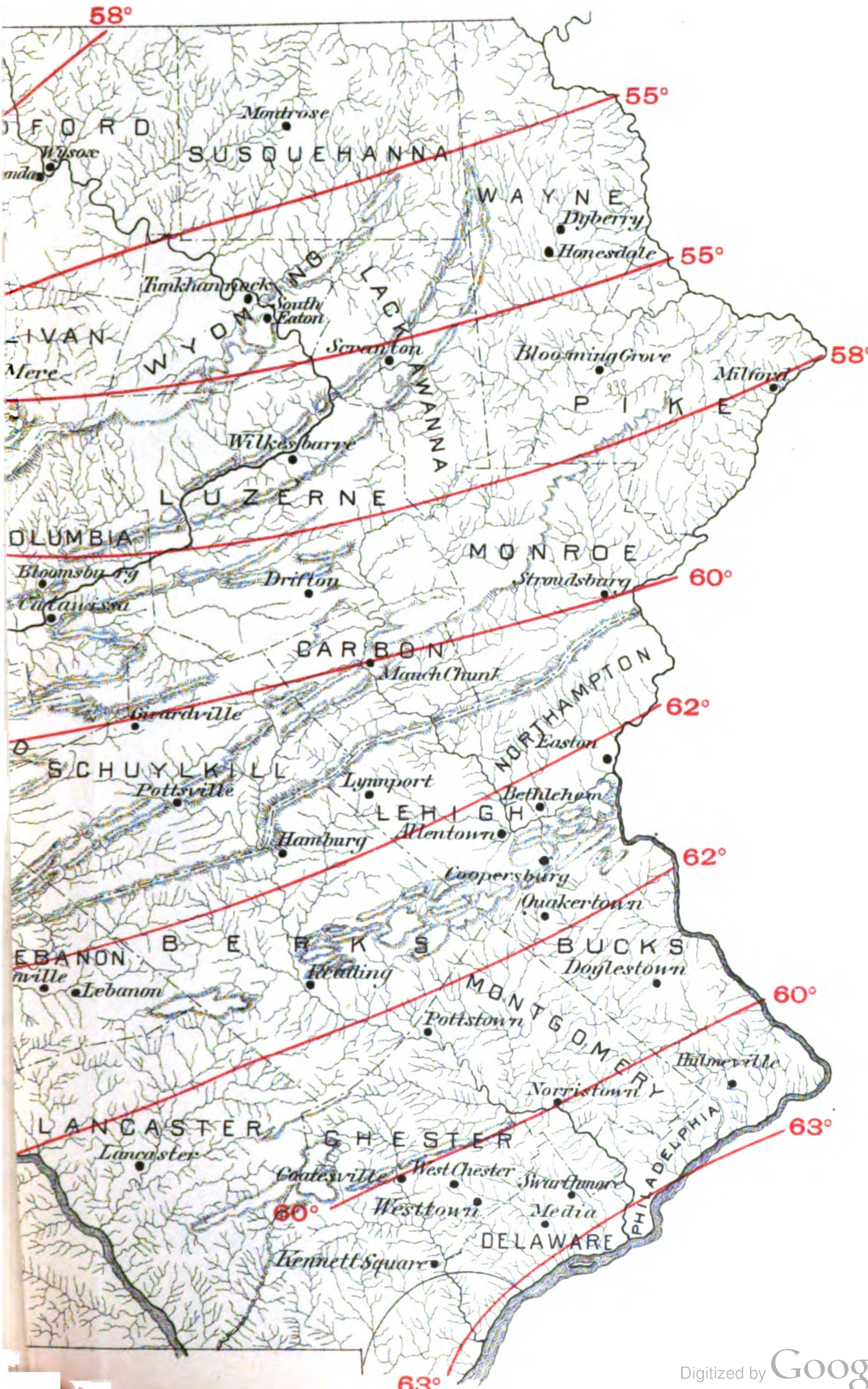
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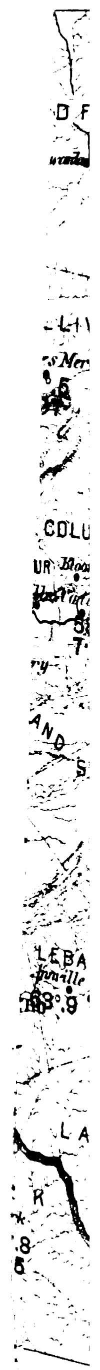

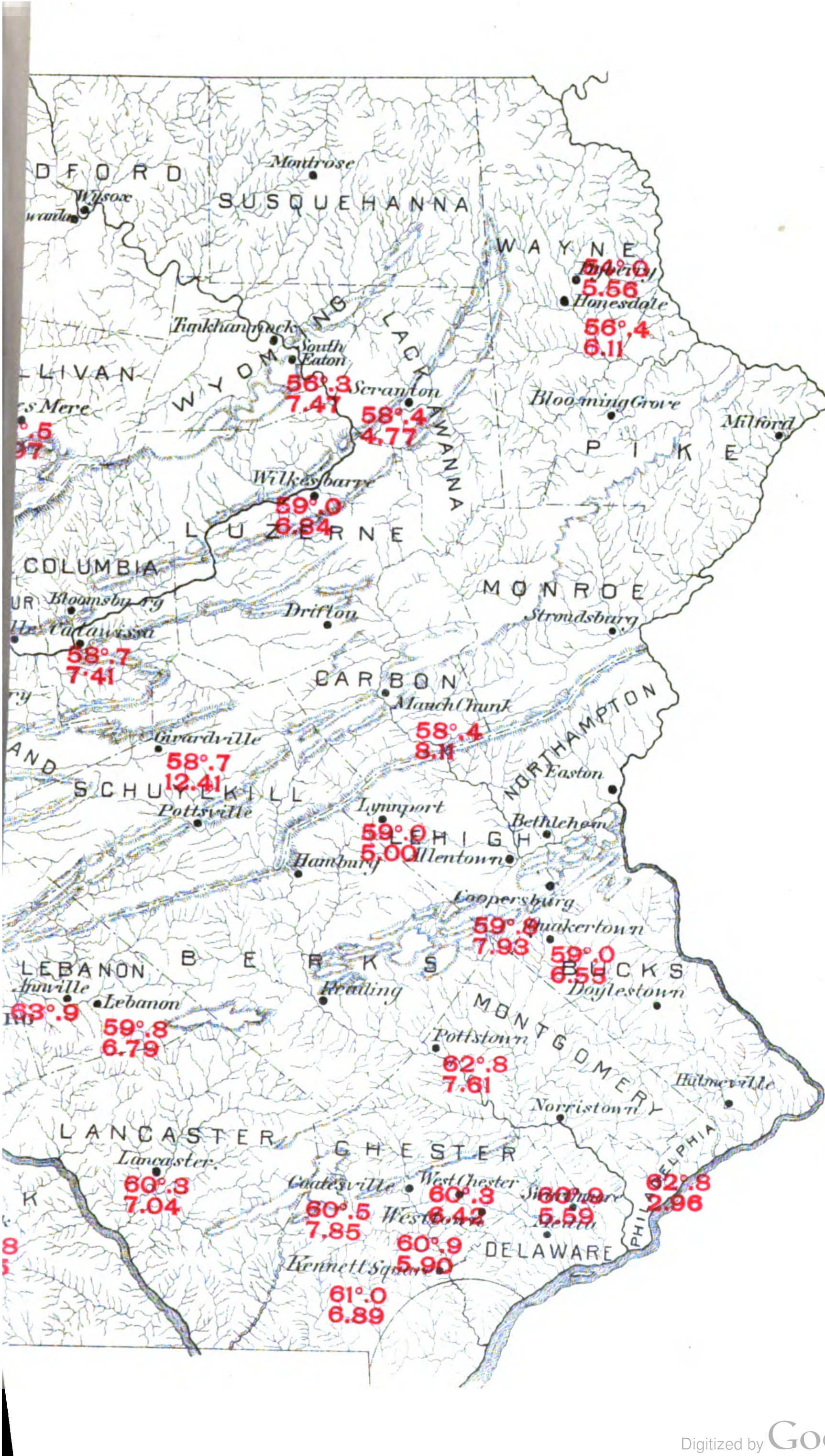
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Hall of the Institute.

JULY, 1890.

Notice is hereby given that the Committee on Science and the Arts of the FRANKLIN INSTITUTE has recommended the award of

The Elliott Cresson Medal

TO

STOCKTON BATES, EDWIN F. SHAW AND GEO. M. VON CULIN,

for their Improvements in

"SUPPORTS FOR SPINNING SPINDLES."

Any objection to the above recommendation should be communicated within three months of the date of this notice to the Secretary of the FRANKLIN INSTITUTE, Philadelphia.

WILLIAM H. WAHL, Secretary.

Entered at the Post Office at Philadelphia in accordance with Section 199 of the Postal Laws and Regulati

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DEVOTED TO

Science and the Mechanic Arts.

EDITED BY

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Third Series. *AUGUST, 1890.* VOL. XCX.—No. 2.

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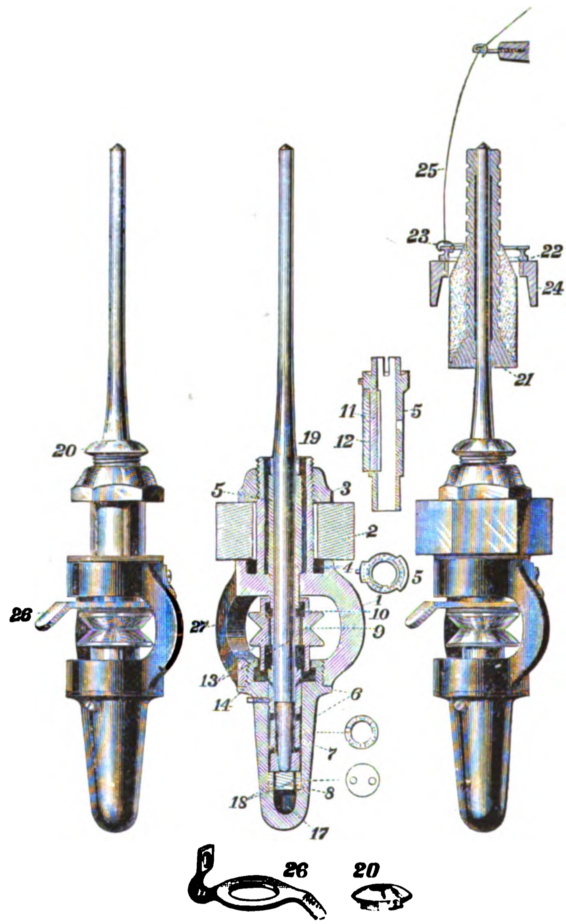

1, Upper section.
2, Bolster-rail.
3, Nut.
4, Oil-receptacle.
5, Upper-bearing.
6, Lower section.
7, Lower bearing.
8, End bearing.
9, Whirl.
10, Chamber in whirl.
11, Steel plate in bearing.
12, Wood strip under 11.
13, Apertures in whirl.
14, Lower rim of whirl.
15, Oil-channels.
16, Oil-channels.
17, Waste-oil cavity.
18, Holes in bearing 8.
19, Spindle.
20, Cap.
21, Cop tube.
22, Ring.
23, Traveller.
24, Ring rail.
25, Roving.
26, Spring.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXX. AUGUST, 1890. NO. 2

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ON STOCKTON BATES' SUPPORT FOR SPINNING SPINDLES.

[*Report of the Committee on Science and the Arts.*]

[No. 1554.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, June 28, 1890.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to whom was referred for examination,

STOCKTON BATES' PATENTED SUPPORT FOR SPINNING SPINDLES,

respectfully report that:

They have carefully examined the same and investigated the state of art under which the invention was made, and find as follows:

That the invention is the subject of Letters-Patent of the United States, No. 416,286 and No. 416,287, both dated December 3, 1889, and granted to Stockton Bates, Edwin F Shaw and George M. Von Culin.

That its purpose is to furnish a better support in which spinning spindles revolve, and whilst supporting the spindle, so as to diminish and avoid the inaccuracies in the rotation due to the springing from unequal tension of the driving-bands, to also furnish more durable wearing surfaces, easily and cheaply replaced when worn, and to provide an efficient means of constant lubrication and exclusion of foreign substances from the wearing surfaces. In addition to these features, the bearings, by reason of their construction, require less framing to support them and are entirely self-contained, and hold their several parts in correct relative position to each other, irrespective of any changes which may occur in the shape of the supporting frame of the machine.

In order that the features of importance and value in this invention may be more clearly understood, your Committee deem it expedient to briefly describe how such spindles were heretofore supported in pre-existing machines for the same purpose, and also to show the beneficial effects which may reasonably be expected from their introduction into use.

The functions of spinning spindles are two-fold. They twist a filament or sliver of roving or carded cotton, which has been stretched out, but not yet twisted, and wind it upon a tube placed upon the spindle, forming what is known as a cop.

In the spinning of yarn, as practised in olden times in every household, the spindle revolved with the flyer or frame, bearing hooks, over one of which the yarn passed to the spool on the spindle, turned with a slightly greater velocity, and this difference produced the winding effect.

In the ordinary spinning wheel the spindle was horizontal, and supported in bearings at each end; the speed attainable by foot-power was limited and never brought out any test of the durability and capacity for work which developed in manufactures as conducted by water and steam-power.

In machine spinning, on the other hand, the spindles are vertical or nearly so.

Power spinning machines may be classified as fol-

lows: Throstle spinning, which resembles the method of the spinning wheel, using a flyer and bobbin; mule spinning, in which a certain length of sliver is paid out by rollers, and stretched and spun, and then wound upon the bobbins; and ring spinning, in which a spindle, revolving rapidly, turns a bobbin with it, inside of a ring having a rim or lip, around which a small loop of metal called a traveller turns, and guides the yarn, as it is twisted, from a sliver of roving, which is steadily stretched and paid out by a series of rollers in the upper part of the machine. The frictional resistance of the traveller upon the ring causes it to turn more slowly than the spindle and bobbin, and as a consequence the yarn winds on the bobbin. The rate of winding is regulated by the weight or size of the traveller. The ring and traveller have a slow up-and-down motion during this operation which causes the yarn to wind evenly on the bobbin. The spindle and bobbin must be concentric with the ring or else a tightening and loosening effect is produced at every revolution, which prevents the equal twisting of the yarn and uniform winding of the cop.

The practice which has prevailed in making and supporting machine spinning spindles, has been to rest the lower end in a step set in a rail, and with a journal above fitting through another rail, known as a bolster rail; rotary motion is imparted to the spindle by a grooved pulley or whirl, turned by an endless band. In ring spinning frames the rings are in another rail, which works slowly up and down in suitable guides, so as to wind the yarn evenly in the cops.

It is obvious that any warping or springing of either of the rails must impair the alignment of the bearings of the spindles, and such impairment of position of the bearings increases the friction, and retards the motion and causes both a diminished quantity and poorer quality of product. Such bearings are exposed to dust and require frequent lubrication.

The invention under consideration is designed to avoid the possibility of such defects and as hereinbefore stated, to secure perfect cleanliness and automatic lubrication, besides facility of adjustment and repair. (*See frontispiece.*)

The Bates spindle support consists of an upper section (*1*), which fits from below through an opening in the single rail (*2*) of the machine frame, resting with a shoulder against the under side of the rail, being drawn up and held in position by a nut (*3*) upon the upper part. An oil receptacle (*4*) is formed around the central portion of the upper part of the bearing, within the shoulder, which receives an absorbent packing, and is in fluid communication with an oil-space in the central cavity, containing the upper bush or bearing (*5*). A lower section (*6*) is screwed into the bottom of the upper section, containing the lower bush or bearing (*7*) and the bottom or end-bearing (*8*) and an oil receptacle. In the upper section (*1*), which is bored out concentrically with the screw and shoulder already referred to, is inserted the upper bushing or sleeve (*5*), extending downwardly into a chamber (*10*) formed in the upper side of the whirl (*9*). A steel plate (*11*) is inserted in the bushing (*5*) on the side receiving the draft of the driving-band, with a wooden strip (*12*) laid under it. The whirl (*9*) has apertures (*13*) made through it, reaching from the upper cavity (*10*) into the lower cavity, through which oil can descend, but cannot be whirled off by reason of the lower rim (*14*) of the whirl extending into a chamber formed in the lower part of the support. A bushing (*7*) removably fitted into the lower part of the support, serves to centre the lower end and a hardened steel plate (*8*), beneath the spindle, supports the weight. The bushings (*5*) and (*7*), which form the bearings, are not made with continuous outer surfaces to fit in the casing portions of the support, but are fluted or grooved so as to provide oil channels (*15*) and (*16*) and chambers between the bushing and the casings.

Below the hardened steel bearing (*8*) there is a cavity (*17*), into which any foreign substances in the oil can subside without injury to the bearing. A cap (*20*), fitted loosely around the spindle (*19*) at the top of the bearing (*1*) serves to exclude dust, and is easily raised by the spout of the oiler. An oil-chamber (*4*) is formed around the bearing, which being filled with an absorbent, saturated with oil, insures continuous lubrication for a long time.

The portion of the bearing surrounding the whirl is

formed with curved pillars and intervening open spaces so as to permit easy access to the whirl for the driving-band, and to afford opportunity for inspection.

An elastic plate of metal (*26*), secured by a screw to the upper part of the bearing at the rear, and extending across the upper surface of the whirl, with a projecting ear at the front, acts as a brake when pressed against the whirl, so that the motion of any spindle can be arrested without affecting that of any other.

It will be seen upon inspection that the spindle is supported through a large portion of its length, down to the portion which the driving band strains upon the whirl, and cannot therefore be sprung or vibrated by the band. The oil is guided steadily from the top to the bottom of the bearing, as the oil chambers are sufficient in size to retain oil for several weeks' running. As a matter of fact, these spindles have been run for six weeks at full speed with only one oiling, as a test, lagging only during the last week. It is found to be safe practice to oil them once per fortnight. Ordinary spindles require oiling at least every two days, usually daily and even oftener.

The bushings in the upper and lower parts of the bearings are easily removed and replaced, and being finished with their internal and external surfaces concentric, they cannot be wrongly adjusted. From their form they are cheaply made accurately interchangeable, so that once fitted with these bearings, a spinning frame can, at low cost, be kept in best efficiency for an unlimited time. When once adjusted concentrically with the rings of the spinning frame, all parts, except the upper shell and nut, may be removed without impairing the adjustment and the bearing may be replaced without interrupting the work of contiguous spindles.

The spindle is so well supported in these bearings as to be incapable of vibration, and once set true with the ring in which it works, it continues to work true.

The speed to which these spindles can be run without heating is far beyond the limit imposed by the properties of the staple to be spun. This, it seems, leaves nothing further

to be desired in respect of speed. All portions of this spindle-support are made to fit concentrically and exact alignment is thus enforced. The finishing of the parts is entirely within the capacity of turret lathes, and can, therefore, be made at low cost, and the parts subject to wear, to-wit, the bushings involve very little material and are easily fitted or finished at slight cost.

Your Sub-Committee have examined many other spindle supports and spindles, and have found nothing comparable with the construction exhibited in the Bates spindle. The proportions and combinations of its several parts are so well arranged, that in repeated trials, a spindle weighing about four ounces was kept running for a period of three weeks, or 180 hours, at 12,000 revolutions per minute, without heating the bearings, with no perceptible vibration, and with only the oil supplied at the outset. Appended to this report* is a statement of trials and observations made by Mr. S. Webber, which, while not entirely satisfactory for reasons which Mr. Webber has been careful to explain in his postscript, are of interest to those familiar with such manufactures, as indicating that not only can improved quality of product, with less waste of material, and greater capacity of machine with the same labor, be procured, but that an economy of driving power should result from the use of the invention.

The invention, as observed at work by your Committee, appears to be simple and effective, of great durability, of easy adjustment, susceptible of renewal of all the wearing parts in each spindle without the trouble of readjustment, and without involving any suspension of the work of other parts of the machine, and for this reason, together with the high speed at which it can safely be run, the invention increases the capacity of the machinery to the limit imposed by the properties of the staple. Furthermore, it secures such a uniform spinning and winding by reason of its accuracy of motion, that the best possible quality of product from the material results, as well as the greatest quantity

* Not published.

in a given time, without requiring any additional labor. Thus the invention economizes cost of production, and since the advantages for such reduced cost for labor in proportion to the product, and such improvement in product, are followed by better weaving and better quality of cloth, with diminished cost, the invention may be fairly considered as a most valuable accession to the comfort of mankind in their second great want—*clothing*—food only taking precedence. In view of these facts, the award of the ELLIOTT CRESSON MEDAL appears to be merited.

FRANCIS LECLERE,
Chairman.

[SIGNED]

PHILIP H. FOWLER,
LUTHER L. CHENEY,
JOHN HALL,
S. LLOYD WIEGAND,
STANLEY LEES,
W. BARNET LEVAN,
SAMUEL WEBBER.

Adopted, June 20, 1890.

[SIGNED] GEO. A. KOENIG,
Chairman pro tem., Com. Science and the Arts.

MODERN CONCEPTIONS OF ELECTRICITY.

BY DR. LOUIS DUNCAN.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *February 3, 1890.*]

DR. DUNCAN was introduced by PROF. E. J. HOUSTON of the INSTITUTE, and spoke as follows:

MEMBERS OF THE INSTITUTE AND LADIES AND GENTLEMEN:

I will try to tell you to-night what I think some other people believe with respect to electricity, or at least I will give so much of their belief as I hold to be sound. But we must begin at some little distance from the main title of my paper, for we will find, I think, that to understand the nature of electrical action we must first understand the general type of the various actions which go on around us.

For the industrial life of mankind is made up of two things, the transformation of material and the transformation of energy. All of our endeavor, all of our labor is only to make more useful to us the things we have already on the earth. The supply of material in the world is practically constant; nothing drops off of it as we whirl through space, and the only thing added is some stray meteorite, insignificant except in the way of a sign or wonder. And it has been known for a great many years that mankind cannot destroy or create matter. So we must be content to take what has been given us, and with a little earnest jugglery to change a mountain into a steamboat, to change dirt into a plate-glass mirror, and to make sugar out of coal tar.

But with respect to energy the case is somewhat different. The earth is constantly receiving energy, constantly losing it, and the amounts very nearly balance. It would be very unfortunate, indeed, if we were for one day to fail to receive our accustomed supply of energy from the sun, and it would be extremely uncomfortable if all the energy received for twenty-four hours were to be bottled up on the earth and not allowed to escape. For the sun supplies the energy that makes life possible here. Although the supply is not constant, yet as far as we are concerned or any agency we are acquainted with is concerned, the same law of limitation holds as holds for matter—we cannot create energy—we cannot destroy it. But we spend a great deal of time in transforming it. By the stored energy in the coal we drive our engines; all artificial light is energy transformed from coal, or oil, or wood to the energy of luminous radiations. And all of the energy we utilize we can trace directly or indirectly to the sun. It is the heat of the sun which causes the chemical changes which make up the growth of plants, and this energy remains in the plant after it has become fossilized and appears again as heat when we burn the coal. The energy of our rivers and streams comes from the sun, too—for its heat vaporizes the water of the ocean and makes the winds which carry it over the land where it falls as rain, and flowing to the ocean again, runs

our mills and factories. The sun is the universal source of energy, and so of life on the earth, and this energy comes to us as radiations, heat and light as we call them when they have suffered other transformation, and as I shall hope to partly prove that these radiations are really electrical, then we see that we have been unconsciously very dependent on electricity, although it is the fashion to speak of it as a matter still in its infancy.

The solar system is losing its energy. There exists to-day not one two-hundredths of the amount which existed when the system was created, and it is a curious question as to where the rest has gone. Perhaps it has helped to make up new systems and worlds, perhaps, beyond the confines of what we call space, the law of conservation no longer holds and the energy is annihilated.

The electrician is mainly concerned with the transformations of energy, and material only affects him as it modifies these transformations. The principal virtue of electrical applications lies in the ease with which they allow transformations otherwise difficult to be made. For example, I have here some pieces of apparatus which will illustrate this. Motor, Geissler tubes, piece of carbon, induction coil and jars. What we want to understand is how this transmission takes place.

For the last half century, the great advances in physical science have been through the application of the law of the conservation of energy. Energy disappears at one place and appears in another form, perhaps in another place. The two quantities are equal, or if they are not equal the difference must be accounted for by some loss which must be discovered. The law leads readily to equations, and these have given results of great importance. But, in the last few years, the attempt has been made to trace the path of the energy, which leaving one place, appears at another. We try to label a given portion of energy—the energy in a given piece of coal, say—and to follow it into the boiler, and then to the engine, and then, perhaps, to a dynamo, and, finally, as electric energy to this electric lamp. It has suffered a number of changes, it has passed through many

forms, but, finally, that individual portion of energy has reached the lamp, and being changed into radiations, has started on a journey causing a shudder of the ether through the universe and reaching the confines of space.

It is by tracing these various actions that we have arrived at our present notions, and we have traced them backward, beginning with the energy after it has become radiant.

Ever since the undulatory theory of light began to be held, it became evident that there must be some substance, pervading all space, which would transmit the vibrations which constitute light. It is evident that if light is vibratory, something must vibrate, and as there is no matter in the space between the earth and the other heavenly bodies, there must be something besides matter filling the space. This hypothetical substance was named the ether, and every later discovery has added evidence as to its existence, until now we may consider the ether as a proven fact. And in late years the notion of the ether has assumed greater and greater importance. Sir William Thomson has advanced the theory that matter itself is but ether under various conditions of motion, and he, together with J. J. Thomson, has in some way proved it. If we can account for matter by modifications of the ether, then ether and energy, with the phenomena incident to them, may give us an entire mechanical explanation of the universe, and we can believe that, as far as this mechanical explanation is concerned, we need but ether and motion. And the importance of the ether to us, to-night, is this, that it seems more than probable that all electrical actions of whatever kind, and however made apparent, are transmitted through the ether and by it; and, indeed, the term electricity itself may very well be a misnomer, and electricity positive and negative may only be two phases of the ether.

This etheric theory is an attractive one. To unify all the phenomena of nature and to refer them to the same cause has been the dream of philosophers for many years. But although the conception is simple enough, the details are to us very complex, partly perhaps, because we are ourselves entangled

in that very complicated modification of ether called matter, and cannot perceive things which in their essence are only too simple for us to grasp.

In order to appreciate the change which has taken place in electrical ideas, let us briefly examine the old notions of what constituted the charge of a condenser, and of how electrical energy was conveyed by a wire. In the first case it was held that when we charged a Leyden jar there was a certain definite amount of the fluid electricity upon it, positive electricity on one coating, negative upon the other. When the jar is discharged the two fluids rush together and neutralize one another with some little noise and heat. The thoughts of the experimenters were concentrated upon the charged bodies. If there were two of them they attracted or repelled one another, this was the important fact. It remained for Faraday to show that the space around a charged body had an important part to play in the phenomenon. Substituting sulphur for air between the coatings of a condenser he proved that the capacity was greatly changed. From that time more and more attention has been paid to the space around charged bodies and less to the bodies themselves, until we have begun to consider the latter as simply serving to make evident to us something which is taking place in the surrounding space. But we will talk further of this in the light of some experiments which I will try later.

Our views about an electric current have also been profoundly changed, but much more lately; indeed, the new ideas have not spread very widely even yet. The old idea was that the fluid electricity flowed through a wire very much as water flows through a pipe. But the new idea is that the energy does not flow through the wire at all. At every point along the wire enough energy passes into it to account for the amount of heating done, but the energy is transmitted by the ether outside the wire. If I am running this motor then the energy used in running it does not pass through the wire at all, but passes from the dynamo at the electric lighting station to the motor through the ether. The wire acts as the core of a disturbance in the ether

making the transfer of energy possible, but not itself transferring it.

But it is in another field of electric transfer that we have learned most about the real actions which go on, and a great part of our knowledge is due to three men—Faraday, Maxwell and Hertz. Faraday was the son of a blacksmith. In his youth, apprenticed to a printer, he read the proof of scientific books passing through the press, and finally so impressed Sir H. Davy that he gave him a position as an assistant at the Royal Institution, where he succeeded his benefactor as Professor of Natural Philosophy, and where he carried on those researches which made him famous. In his endeavors to unify the different phenomena of nature, he was led to look for some connection between magnetism and light, and he found that there was such a connection, the plane polarization of light being rotated in a magnetic field.

Maxwell, drawing his inspiration from Faraday, investigated the propagation of an electrical wave through space, and found that it followed the same laws as do light waves, and the velocity was the same as that of an electrical constant, which, on determination, proved to be that of light. So he advanced the hypothesis that light is really an electrical phenomenon. The proof of the hypothesis, however, rested on the fact that velocity of the electric disturbance was that of light, and that certain other electric constants bore the relation to optical constants that theory indicated. It remained for Hertz, a young German, scarcely thirty years old, to show by direct experiment that electrical waves are practically identical with those of light, and to put the electro-magnetic theory on a firm foundation. His method was to produce electrical waves of very short period, say $\frac{1}{100.000.000}$ of a second, and to directly investigate the method of their propagation. I have indicated on a large scale one way of experiment.

In the first place, if we have two tuning-forks of the same pitch and sound one of them, the other will sound sympathetically as it is called. Air waves are formed by the first fork, and these impinge on the second causing motions, slight

at first, but which are successively added, provided the forks are in tune, until the second fork sounds audibly. If the two are not in tune, the successive impulses are not added, but neutralize one another.

Now, is it possible to try a corresponding electrical experiment, and to do the same thing with electrical waves that we have done with air waves? In the first place, when I discharge this Leyden jar, the only thing we see is a flash of light. But if the energy of this charged jar is really stored up in the ether, then the ether is in a state of strain just as a stiff steel spring would be if it were fastened at one end and the other pulled aside. When we let go the spring, it will vibrate for a while, and in the same way when we let go the electrical strain by discharging the jar there will be an electrical vibration, and as the rate of vibration of the spring depends on its stiffness and weight, so the rate of electrical vibration of the jar depends on its capacity and the self-induction of the discharge circuit. That is, if the jar is smaller the time of vibration is less, and it is smaller for a short than for a great length of wire. So by having a very small capacity and short wire, Hertz has obtained 2×10^8 vibrations in a second; a number comparable with the vibrations of light.

Suppose we have a circuit of wire with a break in it, and suppose I set up vibrations in the circuit; then I have another circuit which also has a break in it, and I can increase the capacity and therefore change the time constant of either circuit by putting these jars in the circuits. Now, if waves are really sent off from the first circuit, and if the two are in tune, then I may get indications in the second. If I put the two circuits out of tune, there will be no indication in the second. You see the results. This experiment shows us that waves of electric energy are transmitted through the space between the circuits, and it is very imperfectly Hertz's method of experiment. With circuits so small that they could be easily carried about, he investigated the direction of the waves and their length. He found that they were reflected like light waves; that they were refractive and, in fact, that they were practically

identical. He directly measured the velocity, too, and found it to be, as nearly as he could measure, the same as that of light. In fact, the evidence is all but conclusive that light is an electro-magnetic phenomenon, and we know that light is transmitted by the ether, so we have at least one form of electric energy, which is transmitted by the ether.

Now, let us take up another form of transmission; namely, along a wire. Here we must try to label the energy coming from the dynamo and follow it to this lamp or motor. Poynting and Heavyside first proved mathematically that the energy appearing in the wire in the form of heat rains down on the wire from the space around it and the matter has an important practical bearing. Suppose I have a tube, open at both ends, immersed in a tank of water and suppose the length of the tube is great compared with its diameter. I can represent with it the old and the new idea of electric currents. If there is a piston in the tube and if I push the piston through, the water which represents the current will move steadily along the tube; the velocity of each point in its section is the same, it will move as fast near the outside as in the middle. If we move the piston back and forth rapidly, we will have a current alternating in direction, but the distribution of velocity will still be uniform. Now, suppose we remove the piston and simply move the tube in the water. If we move it slowly and in one direction, the friction of the sides will carry the water along with it, the current being represented by the rate at which the water passes a fixed point and the distribution is uniform. But if we move the tube rapidly back and forth through a short distance, the condition of the water in the tube will be different according as it is near the centre or near the outside of the tube. If the alternations are rapid and the amplitude is small, then the water near the centre may not move at all. In the first case, we have a current caused by a force acting along the wire; in the second, by a force all along the wire on the outside. The effect is the same for both in the case of a steady motion, corresponding to a steady current and the distribution is uniform across the section, as it is in the case of a steady current through a

wire. But in the case of the alternating forces the results are different; a force along the axis giving a uniform distribution, the force acting from along the outside giving a greater motion near the surface. Which of these corresponds with our experience in the case of alternating electric currents? The last does. With an alternating current along a wire if the period be very small a very little of the current reaches the centre.

Other experiments show the same thing almost conclusively; namely, that the energy of an electric current is conveyed by the ether around the wire. But if the wire does not convey the current, how does its presence affect the ether in its neighborhood? With our present knowledge of the properties of the ether it is impossible to say. We may represent the state of things, if we wish, as Lodge has done. He imagines that the ether is made up of a number of cog-wheels meshing into one another, and he further imagines that a conductor consists of wheels which have no teeth, but whose rims can slip over the cogs with a certain amount of friction, and so with a certain production of heat. If we had nothing but the cogs, we could not make them rotate for they would tend to turn each other in opposite directions and would stick fast. But with a number of wheels over which the cogged teeth could slide, rotation would be possible and we would have a condition of affairs representing a current.

If the wheels were elastic, then, if we try to turn one of them, there being no conductors around, the wheel would turn slightly, and this partial turning would be transmitted to the next, and so on; there being a definite strain through the whole space due to the stretching of these rubber wheels. And Lodge would represent the charging of a Leyden jar by this—the distention of the wheels representing the strain in the ether. We must then consider the charge of a Leyden jar as represented by a partial rotation transmitted through space with a velocity dependent on the elasticity of the wheels and their mass. When we discharge the jar, the wheels are relieved from their strain and oscillate for a while about their position of rest. If we

will consider for a moment, we will see that if there were such wheels half would revolve with, half against the hands of a watch, and this difference in the direction of rotation of the wheels may be taken as in some way representing the difference between positive and negative electricity.

And this model of the ether would in some way explain magnetism. The rotating cogged wheels represent magnetic effects, and if they rotate they must of necessity be included in a current. So we only have to adopt the old theory of Ampère, who supposed magnets were made up of a great number of small currents circulating around the molecules of the magnet and our model fits in with the facts of magnetism also. But no one—least of all Prof. Lodge—believe that this actually represents the mechanism of the ether. It helps us to have some definite notions, and no one has been more helpful than Prof. Lodge. But whatever the exact nature of the actions, there is not any doubt that some motion of rotation in the ether accompanies electrical and magnetic actions, and that electrostatic actions are caused by a strain in the ether.

We have taken up in an imperfect way three types of electric action, or rather four. Electrical waves, electrical strains or static electricity and electric currents, and in the latter we have included magnetic actions, especially if we accept Ampère's hypothesis. There is one thing we have not taken up, and that is the passage of an electric current through liquids. But this I will not take up.

So much for the transmission of electric energy; for its sources we can go in many directions. The largest, most important and cheapest source of electrical energy is the sun. The energy which makes up the organic life on the earth, the energy which causes the growth of every flower and plant and animal comes to us as electrical energy. Through many transformations, after long waiting sometimes, the electrician takes it again; transforms it a second time into electrical energy, and then distributes it for the uses of mankind.

THE METALLURGICAL ARTS AT THE PARIS EXHIBITION.

By F. LYNWOOD GARRISON,
Delegate of the INSTITUTE.

[*Continued from vol. cxxx, p. 51.*]

SAINT CHAMOND COMPANY.

This company, having a capital of 20,000,000 francs, was established at Rive-de-Gier in 1837 by MM. Petin and Gaudit, and afterwards at St. Chamond in 1850. The works are somewhat scattered in groups, the larger portion being between Lyons and St. Etienne, at Givors, Rive-de-Gier, Assailly and St. Chamond. The principal iron works are at St. Chamond, the mills and steel works at Assailly, the forges at Rive-de-Gier and the blast furnaces. with additional works, at Givors. At Boucau, in the southwestern corner of France, near Bayonne, the company have other blast furnaces and steel works; and in Corsica have blast furnaces at Torga, whence they derive excellent charcoal pig iron, which mainly constitutes the steel which makes their armor plates and castings famous. The company employs about 6,000 men, and its operations embrace almost all sorts of iron and steel objects, particularly ordnance, chrome steel projectiles, armor plates, etc.

The company's most important rail mill is at the Adour Works, where there are three large furnaces, two Bessemer converters and rail mills having a capacity of 70,000 tons per year; the ore used comes mostly from Bilbao and Bidassoa. At the same works iron railway sleepers are made in large quantities, wheels of all kinds and locomotives are manufactured at Rive-de-Gier, while the specialty of Assailly is the production of springs of crucible steel. At St. Chamond, ship and boiler plates are manufactured, and here, as at Rive-de-Gier, the heaviest forgings are made. Like the other great works in the Loire Basin, the St. Chamond Company possess special facilities for the manufacture of the highest

grade of war material. The steel ingots are made from the cast iron coming from the company's furnace at Givors and Boucau. Siemens-Martin furnaces are used, and the plant is claimed to be sufficiently large to produce 100-ton ingots.

The 100-ton hammer at these works was built in 1879, it was originally 80 tons, with a piston 75 inches in diameter,

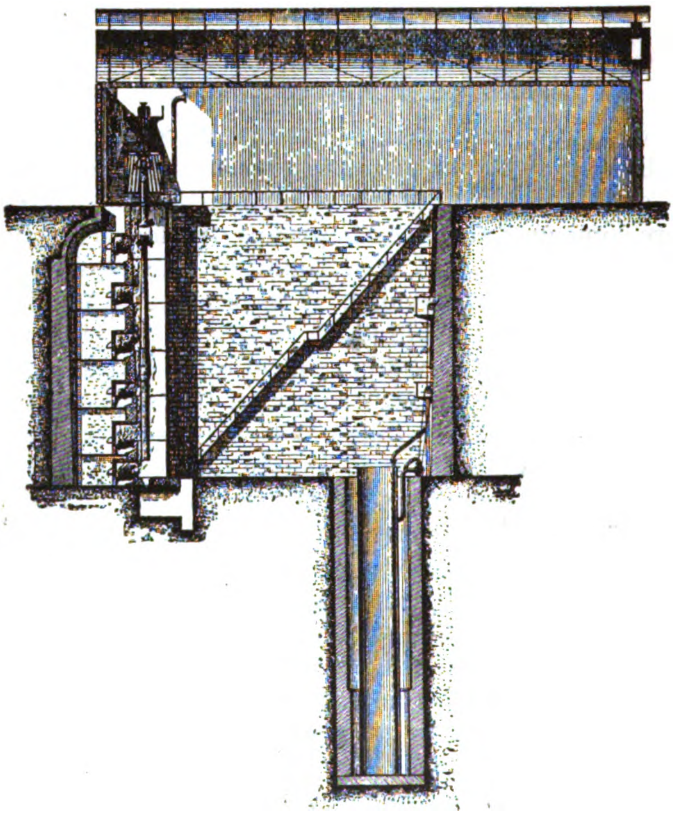

FIG. 8

15¾ feet stroke and an anvil of 800 tons, but the weight of the blow has since been increased to 100 tons. The cylinder is supported upon an A frame, the inclined standards being tied together by heavy horizontal bracing at the level of the guides. A similar arrangement was originally proposed for the new 100-ton hammer for Marrell Bros., at

Rive-de-Gier, but it has since been modified, and curved standards of the well-known Nasmyth pattern, with two horizontal bracings, substituted. The cranes attached to this hammer have a lifting capacity of 100 tons; they are worked by steam.

The tempering shop contains an upright heating furnace, sixty-five feet in length and a well of the same depth, containing the oil bath for tempering, *Fig. 8* shows a section of the same. The furnace is heated by means of six grates, ranged one above the other. The ingot or forging to be tempered is suspended in the furnace by means of a chain from a fifty-ton travelling crane; during the heating it is turned slowly round, and from time to time shifted through a small vertical distance, with the object of securing as nearly uniform heating as possible. When sufficiently heated, the ingot or forging is carried along the pit and lowered into the oil tank, which is about ten feet in diameter, the top nearly flush with the floor of the pit. The lifting and travelling gearing of the crane is worked by steam, but the lowering is effected by some hydraulic means in order to insure a descent and immersion in the shortest possible space of time.

The St. Chamond Company claim to have been the first works in Europe to produce armor plate. It seems most of their productions of this kind are iron and compound plates, solid steel plates not having, as yet, received much attention. The iron plates are made by PILING small bars of a V or W section; the plates thus produced are again piled and rolled. Most of the plates made here are compound, the iron plates made in the manner just indicated serving as a foundation for the steel covering which is welded to them. The heaviest compound plates produced in this manner weigh about forty tons.

For ordnance the ingot to be forged must have a section at least four times larger than the forging when ready to be turned. The weight of the piece after forging is never more than fifty per cent. of that of the ingot used. Before tempering, the steel must have a tensile strength of from twenty-five to thirty-eight tons per square inch, with a maximum

extension of eighteen per cent. After tempering, this is increased to from thirty-four to fifty tons, with from twelve to fourteen per cent. elongation. Most of the steel used for armor plate and ordnance is made in open-hearth furnaces, some with basic and others with acid linings. I believe, however, that the basic linings have given so much satisfaction that they are now used almost exclusively. Bricks of Styrian magnesite are used for the purpose. The magnesite from this locality is found preferable to the purer mineral from the Island of Eubea, as it is slightly ferruginous.

In casting large ingots from the open-hearth furnaces, the casting is frequently begun before the entire charge is received in the ladle, in order to cast as hot as possible.

For cutting armor plate to the finished size circulars saws are used at St. Chamond. They are discs six and one-half feet in diameter, having sockets for receiving the cutting tools, which are arranged in pairs, the first taking out the centre and the second trimming the sides of the cut, which is about an inch broad. The most minute care is required in adjusting the tool, the fitter being provided with a great variety of packing pieces of varying thickness down to strips of paper. These saws will, it is claimed, cut a fourteen-inch plate at the rate of about an inch per hour.

The exhibit of the St. Chamond Company was one of the very best of the works in the Basin of the Loire. Perhaps the most striking object in it was a fac-simile of a 100-ton steel ingot such as are made at these works. These ingots are usually made into gun forgings of the largest size. Very fine specimens of armor plate were also shown; one compound plate weighing over twenty-seven tons forming the top of a turret, with two embrasures worked in the plate for six-inch guns. Plates of this kind are shaped under hydraulic presses, then the embrasures worked out under the hammer. A few iron and steel plates of exceptional size were exhibited as specimens of what work can be done at the company's rolling mills. One of these was of iron, 32 feet long, 9 feet wide and 0·63 inches thick; another of steel, 46 feet long, 6 feet wide and 0·63 inch thick. Two other

plates of soft steel remarkable for their extreme thinness; one was 19 feet long, 39⅛ inches wide, and 0·08 inch thick.

A crank-shaft for a marine engine weighing fourteen tons was exhibited; it was one of the first of such large dimensions made in one piece. The largest gun forging exhibited was a tube for a 13·39-inch gun, 36 feet long, weighing 14 tons; this tube was bored, tempered and turned to within 0·08 inch of its final size.

The following are the tests of this steel after tempering: Breaking load, 41·90 tons; elastic limit, 22·86 tons; and extension, 15 per cent. Another specimen for a 5·51-inch gun weighing two tons was tempered in water, the results shown greater hardness and less elasticity; they were at the breech, breaking load, 50·79 tons; elastic limit, 29·21 tons; and extension 12 per cent.; at the chase 53·97 tons, 31·75 tons, and 10 per cent., respectively.

Perhaps the most interesting gun forging in the exhibit was one for a 14·57-inch gun *forged on a mandrel* under a steam hammer. This method of forging seems to have been introduced by the St. Chamond Company in 1888.

In a show-case were exhibited a series of fractured specimens of steel used for various purposes. The following table gives a general idea of the characteristics of each: *

	Carbon.	*Silicon.*	*Manganese.*	*Sulphur.*	*Phosphorus.*	*Ultimate Strength.*	*Elastic Limit.*	*Elongation.*
						tons per sq. in.	*tons per sq. in.*	*per cent.*
(1) Sample of steel for car tires (Paris, Lyons and Mediterranean R. R.), ...	·30	·15	·50	·018	·02	31·75	15·87	22·
(2) Steel for locomotive tires (Paris, Lyons and Mediterranean R. R.), ...	·40	·15	·60	·012	·02	38·09	20·23	22·
(3) Steel for special quality of tires, ...	·55	·16	·55	·010	·005	44·44	25·40	18·
(4) Steel for naval guns, . . .	·48	·21	·55	·007	·009	41·27	22·86	22·
(5) Steel for axles, ...	—	—	—	—	—	29·21	15·24	25·
(6) Chrome steel for tires, . . .	—	—	—	—	—	50·79	30·48	13·5
(7) Steel for tires (tempered and reheated), ...	—	—	—	—	—	43·17	—	16·
(8) Same as No. 2, ...	—	—	—	—	—	38·09	24·73	20·
(9) Special steel for locomotive tires, ...	—	—	—	—	—	44·44	24·76	15·

* I have copied this table from *London Engineering*, September 20, 1889, p. 347.—F. L. G.

Amongst the railway material in this exhibit was an interesting series of steel tires:

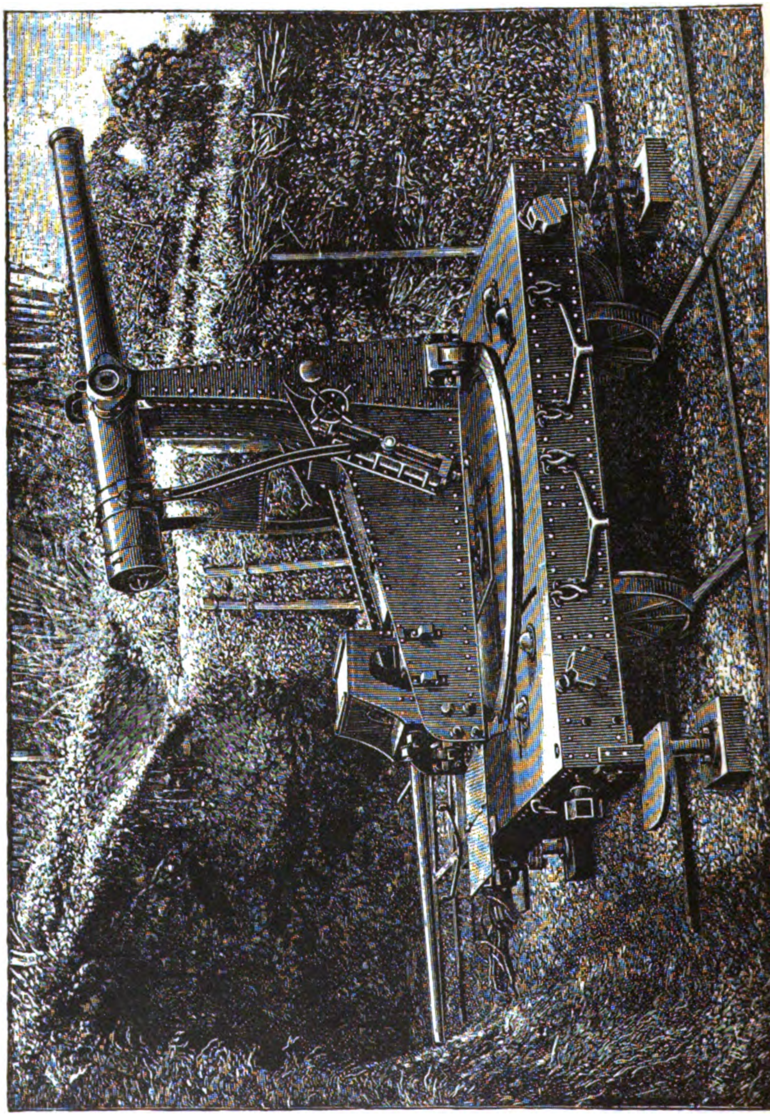

FIG. 9. **Siege Gun, with Barbette Carriage and Revolving Platform.**

(1) 54·33 inches in interior diameter, 5·62 inches wide, and 3·66 inches thick; it withstood the regulation test of four

blows from a 2,200 pounds weight falling through a height of 8 feet 9 inches, and afterward twenty-three blows from the same weight falling from a height of 32 feet 9 inches. The tensile strength was 41·65 tons per square inch, elongation, 21·5 per cent. (2) 32·29 inches in internal diameter, 5·19 inches wide, and 2·44 inches thick; withstood three blows of same weight falling same distance, and seven blows falling from a height 32 feet 9 inches; tensile strength 32·51 tons, elongation 27·5 per cent. As an example of the work which can be executed by this company, an iron ring was shown, 6 feet 7·76 inches in diameter, 14·37 inches wide, 3·82 inches thick, and weighing 3,968 pounds.

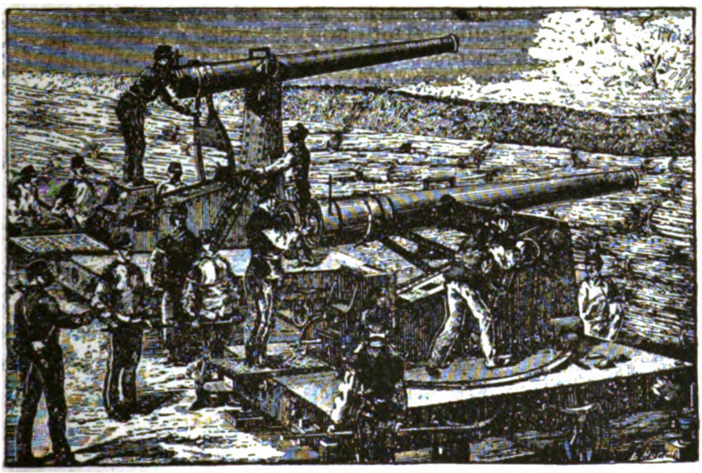

FIG. 10. **Siege Gun, with Barbette Carriage and Revolving Platform.**

The St. Chamond Company's exhibit of war material may, for convenience, be divided under six heads: projectiles, armor plates, small arms, gun carriages, heavy ordnance and turrets. A series of three shells were shown, illustrating a method of manufacture peculiar to the company; they are forged hollow out of a block and shaped in a hydraulic press, the rear of the shell being closed solid by the same means. Some of the projectiles shown had been subjected to severe tests with but little deformation and damage. The largest of them, a shot 16·54 inches in diameter, had

penetrated a plate 19·69 inches thick, the angle of firing being 20°. Another, 13·39 inches in diameter, passed through a steel plate 15·75 inches thick, the angle of fire being normal.

The armor plates were equally interesting, the largest, a compound plate, weighing nearly fifteen tons, and from twelve to thirteen inches thick, had received three shots, which penetrated to depths of 5·82, 4·52 and 5·31 inches. The next plate was somewhat larger, but not so thick, being 4·72 inches and weighing seven and a half tons.

The St. Chamond Company claim that the iron armor plates manufactured by them will resist, without any serious deterioration, a great number of rounds fired at the same spot; it being understood, of course, that the thickness of the plate is proportioned to the energy of the shot fired against it.

Amongst the exhibit of small arms, was a rapid-fire gun on the Daudeteau system, 1·85-inch bore and 45 calibres in length. The breech mechanism of this gun is an interrupted screw and not a wedge, the opening and closing action being very simple. The weight of the projectile is about three pounds, and the initial velocity 2,000 feet per second. Several 3·15-inch mountain guns were shown, the weight of each complete was 273 pounds. These guns are said to throw a twelve-pound shot with a muzzle velocity of 1,000 feet. This type of gun is made in two sections, which are screwed together and a tight joint maintained by a tight metallic ring; the breech action is on the De Bange system. The carriage is divided into four parts: the body, the framing carrying the axle and trunnions, the hydraulic brake, and the two wheels. The maximum weight of any separate part does not exceed 140 pounds. A regulation 3·15-inch field gun was also exhibited. This gun gives a muzzle velocity of 1,600 feet. The total weight of gun and carriage complete is one and a half tons.

Two samples of siege artillery were exhibited. A barbette carriage, mounted on a revolving platform (*Figs. 9* and *10*). This type of carriage is used for guns of from 4·72 inches to 5·30 inches bore. It will be observed that the

gun is mounted at the upper end of a frame, which can be turned around a horizontal axis secured to the main carriage, which is mounted on a platform, free to turn round a central vertical pivot. The recoil causes the gun to fall about forty inches. A rifled mortar of the light 6·10-inch type, 5 calibres in length, fitted with the De Bange breech was also exhibited. This gun fires a ninety-pound projectile with a muzzle velocity of 650 feet, the angle of fire varying from 5° to 60°.

Heavy coast and naval guns were exhibited, partly in models and partly in actual objects. They include a model of a 10·82-inch (275 millimetres) coast gun *Fig. 11*, a naval

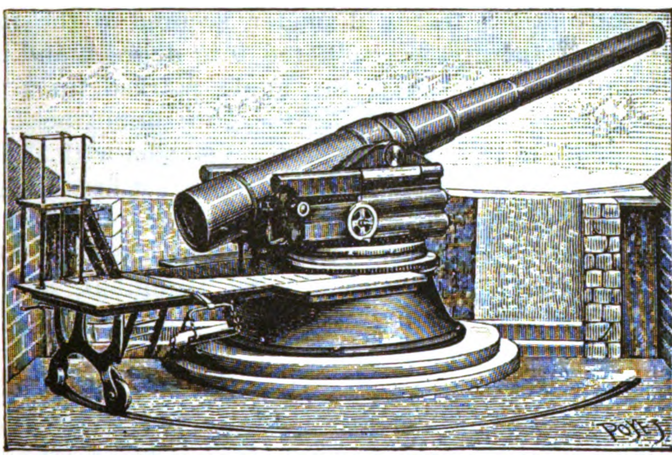

FIG. 11. Twenty-seven-and-one-half-centimetre Coast Gun.

7·87-inch (200 millimetres) gun *Fig. 12* (shown in firing position), and a naval 6·10-inch (175 millimetres) gun, all mounted on a forward pivoted naval carriage.

By far the most interesting part of the St. Chamond Company's exhibit of war material were the models of the Mougin armored turrets. The one shown in *Figs. 13–17* is 19 feet 8 inches in internal diameter, the roof protected by 9·45-inch domed plates of armor, and arranged to receive two 5·90-inch guns.* The outer and lower part of the turret

* The construction shown in *Fig. 17* differs slightly from the others.

is made in segments of hard cast iron about a foot thick; the inner and moving part of the turret consists of an iron frame-work, on which are carried the guns, carriages, and armor plates protecting them. This structure rests on twelve vertical wheels, and is guided by ten horizontal centring wheels. Most of the weight, however, is carried upon a hydraulic piston, so that the wheels have but little load to support. A winch in the masonry base of the structure serves to turn the turret; a complete revolution can be made in one minute. Smaller winches are placed near the guns to raise the ammunition. The guns are fired automatically by a very ingenious arrangement. A large brass ring about fourteen feet in diameter, secured to the inner walls of the structure, is graduated into degrees and minutes; pointers are placed at the angle marked upon this ring, at which it is intended that the gun should be fired; they are brought in contact at each revolution with the terminals of an electric battery, and this contact fires the gun the instant its axis enters the angle desired. An interesting design for an oscillating two-gun turret was also shown. The turret is hung upon horizontal trunnions, and the required oscillation obtained by hand after the guns have been loaded and trained; after firing, the turret is returned to the ellipse position, which, it is claimed, can be done in five seconds. The movement of the turret is effected by a drum fixed to the movable portion and by two cables coiled round it in opposite directions, the ends of which are attached one to the drum and the other to a fixed part of the turret; two or three men are sufficient to move the structure, thus rendering any other means of power unnecessary. The ends of the guns not projecting beyond the turret, and the embrasures being very small, the structure is obviously well protected from hostile fire. The guns are not mounted on carriages; the trunnions, which are movable between the two sides of the curved slides, describe, when the gun is being trained, the arc of a circle whose centre is near the muzzle of the gun; the latter being balanced, this movement, which ranges from 1° to 25°, is obtained without any difficulty. The principal operations in this type of

turret, such as training the guns, turning the turret and maintaining the supply of ammunition, is much the same as already described, except the whole work is done by five men and one officer.

The St. Chamond Company exhibited a model in relief illustrating the remarkable system of fortification advocated by Mougin. The chief feature of the system consists of a huge monolith of concrete, in which are constructed the various chambers of the fort and the foundations of the turrets by which it is defended (*Fig. 18*). The details are

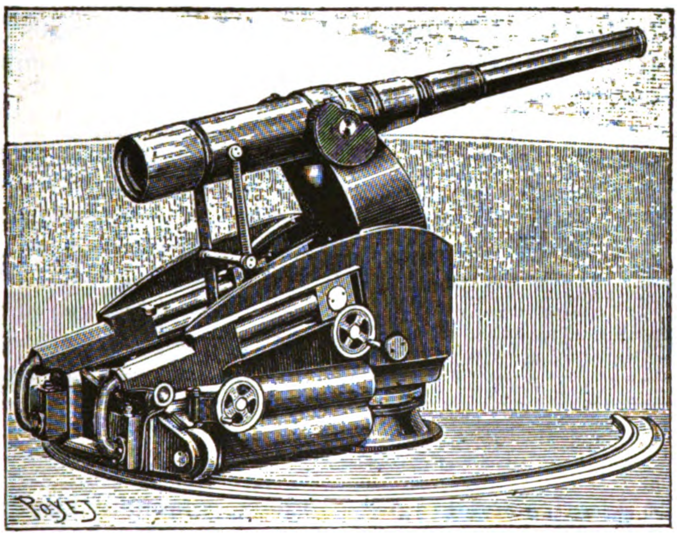

FIG. 12. Twenty-centimetre Naval Gun.

shown better in *Fig. 19*. There are eleven turrets in all, one eclipse turret, containing two six-inch guns; two turrets for all around fire, armed with similar guns; four eclipse turrets for rapid-fire guns, and four eclipse observatory turrets. The middle of the fort is protected by ten feet of concrete, under which is what might be considered as the barracks, the stores and magazines, which would thus be concentrated and could always be under the personal supervision of the commander; the strength of the garrison does not exceed fifty or sixty men. Access is obtained

to the fort by means of a covered way about 70 to 100 feet in length, and a well with stair-case 60 to 70 feet in depth. The top of the stair-case is enclosed in a cylinder carried on a rod having a rise and fall of about six feet. The top of the cylinder is protected by armor plate. When the piston-rod is raised, access to the stair-case is obtained; when the cylinder is lowered, the armor plate at the top protects the entrance from hostile fire. "This system of defence has been very carefully worked out in all its details, both from a military and sanitary point of view." *

A series of interesting samples of ferro-chrome made at the Adour branch of the St. Chamond Company's works were exhibited. The percentage of chromium ranges from 44·30 to 65·20. The following table gives the complete analyses of twelve of the samples:

	1	2	3	4	5	6	7	8	9	10	11	12
Chromium, . . .	62·70	64·80	6[illegible]·39	64·00	44·30	57·00	64·50	63·00	51·10	55·50	65·15	65·20
Iron, ...	25·00	21·80	28·10	23·40	45·00	30·95	24·00	25·38	39·10	34.20	22·00	21·90
Manganese, . . .	0·43	0·43	0·45	0·52	0·80	0·56	0·20	0·42	0·40	—	0·52	0·38
Carbon, ...	11·25	12·00	9·55	11·10	8·50	9·38	10·50	10·05	6·75	9·10	10·52	11.80
Phosphorus, . . .	0·06	0.06	0.06	0·06	0·06	0·06	0·06	0.06	—	0·06	0.06	0·06
Silicon, ...	—	0·50	0·60	0·49	1·40	0·45	0·40	0·40	0·32	0·56	0·55	0·38

UNIEUX STEEL WORKS.

The Acieries and Forges d'Unieux, commonly known as Jacob Holtzer & Company's Works, were founded on the Loire, in 1829, by Jacob Holtzer, and since his death have remained in the family. In the beginning the establishment was on a very limited scale, and the output was confined to high grades of steel for tools, springs, etc. The works were gradually enlarged, and it was here that the first puddled-steel furnaces in France were constructed.

The works now employ 1,000 men, and consume about 40,000 tons of fuel per year. Much of the pig iron used by the company is made in their charcoal furnaces at Ria

* *Engineering*, October 4, 1889, p. 403.

(Pyrénées-Orientales); they also use ore from Thorrent, Sahorre and Escaro. In the manufacture of cutting tools only the best quality of Swedish charcoal pig is used. The works contain seven Siemens gas crucible furnaces, each holding thirty sixty-pound crucibles, so that ingots from five to six tons can be cast; the total daily production ranges from thirty to thirty-five tons. The pots are somewhat thicker than those used in coke furnaces; ordinarily, they will last longer than when coke is used for fuel, as the gas does not cut them like the coke ash. From six to ten heats is the usual run. There are ten reheating furnaces in different parts of the works, for the rolling mills and steam-hammers. There are twelve cementation furnaces (one-half the total number in France in 1887), for the production of blister steel, six thirty-ton and six fifteen-ton capacity; 2,500 tons of blister steel are produced by these furnaces annually. The new portion of the works contains a 2,000-ton hydraulic forging press, made by Messrs. Davy Bros., of Sheffield; the same building contains one fifty-five-ton and one fifteen-ton travelling crane.

The annual production of the works, prior to the extensions which have just gone into operation, is about 4,000 tons of crucible steel, used mostly for tools and other similar purposes. This company has long been celebrated for their chrome steels, of which three grades of hardness are produced. They were the first works in Europe that produced chrome steel. The tungsten (wolfram) steel, for which they are equally celebrated, they claim does not require tempering. Messrs. Holtzer & Co. make a specialty of cast-steel rifle barrels, which they are now producing at the rate of 45,000 per month, for the Lebel rifle. About 500 tons of special castings for machinery, 300 tubes for heavy guns, and 200 tons of chrome-steel plates, are produced annually.

In 1882, the Holtzer Company commenced the manufacture of chrome-steel projectiles.

The first trials were made in July, 1882, with a 13·4-inch projectile, which was fired against a 15·75-inch iron plate at an angle of 18°; three such projectiles passed through

the plate and backing, one of them remaining uninjured. In 1884, the French Marine Department carried out a series of trials with 13·4-inch projectiles, supplied by various makers, the targets being steel plates made at Creusot, and compound plates sent from Sheffield; the Holtzer projectiles passed through both types of plates, 15·75 inches in thickness, without breaking up, a result that again surpassed all previous results, and decided the adoption on a large scale of this class of shot. Since that date, iron armor plates have been entirely abandoned for testing purposes in France in favor of the solid steel plates. At the Exhibition, a remarkable example of these projectiles is shown; it is a

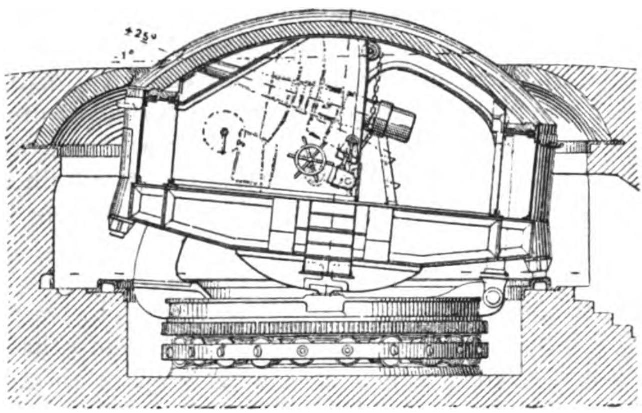

FIG. 13.

10·63-inch shot, upon the firing of which depended the acceptance of a lot of 275, last April; this shell passed through a steel plate 9·84 inches in thickness, made at Creusot, and was picked up 300 yards beyond the plate in a perfect condition, its length having been reduced ·08 inch, its diameter enlarged ·024 inch, and its axis twisted ·08 inch. Some years after these trials had resulted in the adoption of chrome-steel projectiles in France, the English Admiralty became interested in the subject, and since that date has been among the regular customers of Holtzer & Co.

Perhaps the most interesting exhibit of the Holtzer Company at the Exhibition was a series of projectiles of various calibres, which have been fired through armor plates of

different thicknesses, placed side by side with similar projectiles which have not been fired at all. Excepting for a few scratches at the apex and on the sides, the projectiles which have been fired through the plates show little deterioration.

The following description of "*ferro-chrome*" and chrome steel, by M. Brustlein, of Holtzer & Co.'s, will be found interesting in this connection: *

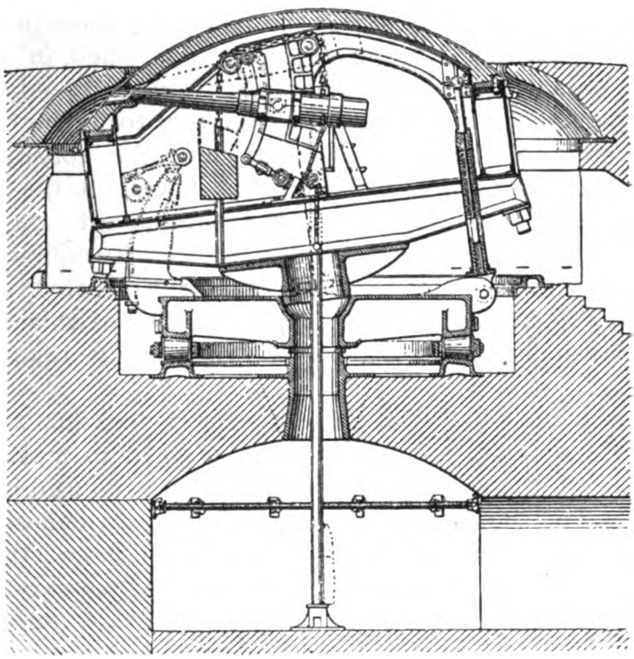

Fig. 14.

Alloys of iron and chromium, containing more or less carbon, have long been known as laboratory products. Berthier makes mention of chrome steels in his memoir published in 1820, and laid stress on the method of making ferro-chrome, predicting that it would be used to introduce chromium in cast steel.

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* Paper read before the International Congress of Mines and Metallurgy, held in Paris, September, 1889.

Later, Boussingault devoted some attention to this subject, and especially showed the presence of three to four per cent. of chromium in the castings made prior to 1867 in the neighborhood of Medellin, in the Province of Antioquia, South America.

It was in the United States that these steels were first produced to any extent for industrial purposes. In 1875, on beginning my tests at the Holtzer works, I had read that chrome steels of great resistance had been made in Brooklyn. Mr. Rolland, mining engineer, published, in 1878, a report on its manufacture as conducted in Brooklyn. In consequence of our tests, we began in 1877 to deliver chrome steel to our clients, and since that time the consumption has grown more and more extended. Owing to the results obtained by us, other steel works entered into the same field; but we were certainly the first in Europe to make this product industrially. Thus we have created a new division of our industry, and the exploiting of this branch has been profitable to most of the large works in our territory.

During the first years of our experience, rich chrome iron did not exist; indeed, we were obliged to make them ourselves in crucibles. Later, they were produced in high furnaces and small blast furnaces, having a richness of 60 per cent. of chromium, and sometimes even more. In order to obtain products of greater richness, it is necessary to use pure sesquioxides of chromium, which are expensive, besides with such proportions of chromium the metal fuses with too great difficulty to be treated in industrial work.

We have collected a series of samples of chromes and ferro-chromes, of which we give herewith the description:

Sample bar No. 2, obtained by reducing sesquioxide of chromium, without excess of carbon in a magnesia crucible.

	Per Cent.
Chromium,	84
Carbon,	9

The bar contains holes, the presence of carbon tending to show that the reduction had not been completed.

Sample bar No. 6, obtained by reducing sesquioxide of chromium in a graphite crucible.

	Per Cent.
Chromium,	82
Carbon,	7·5
Silicon,	8·2

Sample bar No. 1, obtained by reducing sesquioxide of chromium in a brasqued crucible.

	Per Cent.
Chromium,	80
Carbon,	11

Sample bar No. 3, of rich ferro-chrome, containing very little carbon.

	Per Cent.
Chromium,	71·5
Carbon,	3·46
Iron,	20–25

No. 4.—Ferro-chrome, cast in the crucible furnace of the works.

	Per Cent.
Chromium,	60
Carbon,	8·6

No. 5.—Ferro-chrome, poured in chill for ordinary use.

	Per Cent.
Chromium,	50
Carbon,	8

Nos. 7 and 8.—Silico-ferro-chrome. No. 7 cooled slowly and No. 8 poured in chill.

	Per Cent.
Chromium,	30
Silicon,	8
Carbon,	5

No. 9.—Poured in chill.

	Per Cent.
Chromium,	42
Carbon,	7·3
Silicon,	2·1
Manganese,	0·4

This specimen serves to show the special shiny fracture of the metal.

Nos. 10 and 11.—These two specimens have the same richness in chromium, but differ in the contents of carbon.

No. 10—

	Per Cent.
Chromium,	30
Carbon, to saturation.	

No. 11—

	Per Cent.
Chromium,	30
Carbon,	4·7

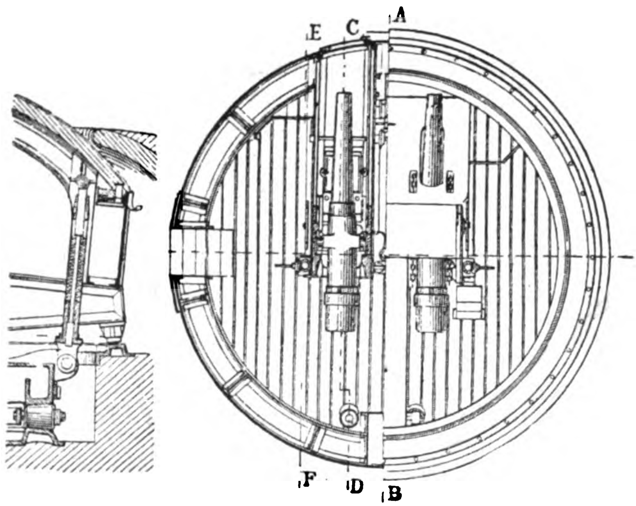


FIG. 15.

Nos. 12 and 13 do not differ, except that No. 12 cooled slowly, and that No. 13 was poured in chill.

	Per Cent.
Chromium,	25
Carbon,	30

In No. 12, white needles are detached in a very apparent fashion on a gray casting. I estimate that there is not enough carbon to saturate all of the mass and that the white needles are formed at first and more carbonized than in the cast.

Nos. 14, 15 and 16.—These three numbers have the same contents of chromium, fifteen to sixteen per cent., but No. 14 is saturated with carbon, while Nos. 15 and 16 do not contain more than two to three per cent. No. 15 is cooled slowly, and No. 16 is poured in chill.

Nos. 17, 18, 19 and 20.—These four numbers have the same contents of chromium; that is, twelve per cent. No. 17 is saturated with carbon, while the three following numbers only contain two per cent. No. 18 is cooled slowly, while No. 19 is poured in chill, and No. 20 is the same as No. 19 drawn out in bars. This shows that a metal with twelve per cent. of chromium and two per cent. of carbon may be

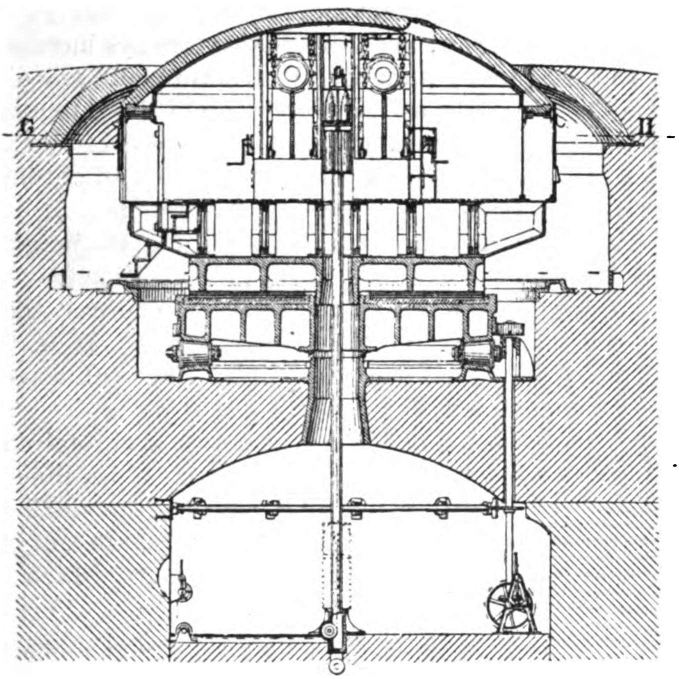


FIG. 16.

forged if one operates with precaution and is found on the line of separation between the steel and the casting.

Nos. 21, 22 and 23.—These three samples all contain about seven per cent. of chromium. No. 22 only contains 1·25 per cent. of carbon. Nos. 21 and 23 have the following composition:

	No. 21.	*No. 23.*
Chromium, about, ...	7·	7·
Carbon, ...	5·	4·5
Silicon, ...	0·4	0·25
Manganese, ...	0·38	0·36

From the foregoing, it appears that the chromes and the ferro-chromes may be combined with large proportions of carbon, much greater than those that are found in ferro-manganese. The appearance of the fracture of ferro-chromes differs more according to their contents of carbon and silicon than with their contents of chromium. Also, it is very difficult to determine at sight the proportion of chromium of a ferro-chrome saturated with carbon or with carbon and silicon. When they are strongly charged with carbon, or with carbon and silicon, they always have a tendency toward having an acicular structure, and are always hard and brittle. But as the proportion of these two metalloids diminishes, the hardness and brittleness of the alloys grow less. Thus No. 3, containing 71·5 per cent. of chromium, is less brittle than the adjoining specimens. It has a bluish tint, scratches glass more easily than its neighbors, and the fracture shows small faces, and is not acicular. It is very strongly attracted by the magnet, whereas, the preceding specimens are not sensibly affected. It is, therefore, principally the carbon and silicon that influence the action of the magnet.

With a composition of sixteen per cent. of chromium and of 2·7 of carbon, such as No. 15, the acicular crystalline form is replaced by small rectangular cleavage or small faces arranged in steps, giving to the fracture a chatoyant effect, which varies according to the angle from which it is examined.

We know that rich ferro-manganese that has been allowed to cool slowly shows on shrinkage needles similar to those of ferro-chrome; and in manganese castings it is not until their contents in manganese fall below ten per cent. that these large specular faces appear, which have been given the name of spiegel. It would be of interest to ascertain whether poor ferro-chrome which is saturated with carbon would possess this peculiarity of imparting to its fracture these large specular faces.

It was especially for this purpose that in preparing samples I made those containing so small a proportion of chromium.

Thus No. 21 shows no such faces, while in No. 23 the peculiar crystallization of spiegel, but of spiegel with faces slightly straited, is very greatly developed. These two samples only differ by the proportion of carbon and silicon that they contain; therefore we are tempted to attribute to the influence of silicon the absence of faces in No. 21. Nevertheless, it will require a great number of trials in order to draw a conclusion.

Besides, the question appears to be of interest from the following point of view:

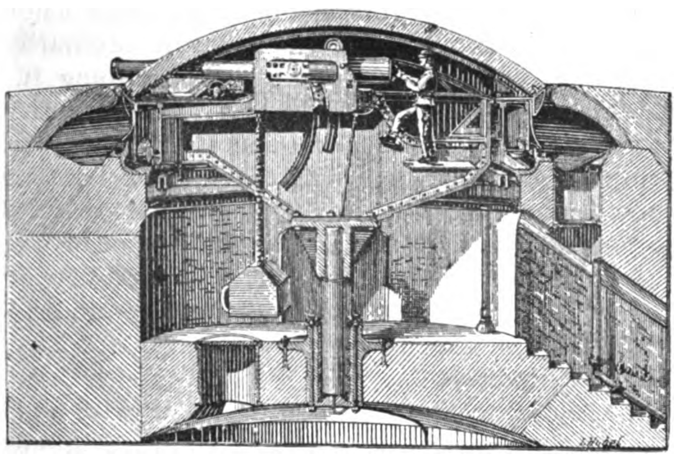


FIG. 17.

Steel only differs from cast iron by a small proportion of bodies foreign to iron; hence, it is natural that these bodies should possess in themselves certain properties which they impart to steel having an analogous relation to those which they give to cast iron.

Thus we see that manganese united to carbon produces in cast iron those enormous cleavages which distinguish the spiegel and remove all solidity from the metal; and hence we should fear that, in a carbonized steel, the manganese favoring the crystalline development would injure, for that reason, the solidity of the metal, which, in reality, does take place. The same observation applies to silicon, but in an inverse sense; that is to say, by preventing the

crystalline development. For ferro-chromes, the tendency of chromium to give the specular aspect to cast iron is slight—in any case, less than in the manganese—which makes it possible to prevent this metal from having the same objectionable features that the manganese does.

Experience goes to prove this condition of affairs. There may be introduced varying proportions of chromium of which the effect is to increase the resistance of steel without diminishing the tenacity corresponding to its carbon contents, and even, it appears, to slightly increase that tenacity. In consequence, it is possible to obtain, with a resistance given to the rupture, a bending corresponding to that which is obtained with a steel that is ordinarily less resisting or softer: that is to say, in describing it, as a metal which, well handled, offers a very great security.

At the forge, an ingot of chrome steel may be worked with no more difficulty than with ordinary steel of the same hardness; nevertheless, when hot, it offers a greater resistance to deformation. When an ingot is cut hot by a cutter, the metal is more ductile; the point of contact between the two pieces is flattened out into a thin web before breaking. It is influenced by the fire even less than an ordinary steel of the same hardness.

In the cold, when worked on a lathe or with a plane, a steel containing, for instance, two per cent. of chromium is always a little harder to cut than ordinary steel; nevertheless, if it is properly reheated the difference is not great. Steel that contains less chromium, even when it has one per cent. carbon, may be worked without difficulty on a lathe. Tempered with oil or with water, the temper penetrates more deeply than in a carbonized steel of the same degree of carbonization without chromium.

The particulars which present themselves during the heating and cooling, during the passage of carbon from the combined state to the dissolved state, have been studied by M. Osmond, who compared it with other steels in his interesting researches on this subject.

To continue, chrome steels offer a resistance to shock and to fracture which for the time being have the prefer-

ence for a certain number of uses. On the other hand, when once made into ingots, it can be manipulated like ordinary steel; which is an additional advantage. But they offer in their manufacture difficulties of a special nature. In a state of fusion which takes place at high temperatures, the chromium which it contains has a tendency to take up oxygen from the air. For in such case there is not formed, as is the case with oxide of manganese, a liquid and fusible silicate lighter than steel, which comes rapidly to the surface. It would be supposed that there would be a tendency to form a chromite of iron; in any case, chromium, in burning, causes in its immediate neighborhood the decarbonization of the steel and the oxidation of the iron, giving rise to a creamy layer, of which the little fragments rest readily not only on the edges of casting pot, but even in the mass of the metal. This effect is heightened when the contents of chromium is greater, and when the steel itself is poorer in carbon. The portions thus oxidized will not unite under any working, no matter to what temperature they may be heated.

For the same reason, the layer of oxide which is formed on heating the ingots or bars is stronger and adheres closer than in ordinary steel, and does not easily dissolve in borax. Also, chrome steels only unite with difficulty or not at all, according to amount of chromium they contain. Hence, it is assumed that a metal containing much chromium is undesirable for puddling. As a matter of fact, every lump of refined metal that is made becomes surrounded with an oxidized pellicle, which adheres to it and is, in consequence, insoluble, so that under a shingling hammer it is impossible to collect these lumps in a proper and coherent mass.

Although we have not tried it, we are persuaded that every attempt at puddling will encounter the difficulty that we have described. Ferro-chromes are, as a usual thing, very strongly carbonized, and hence it seems natural to consider their use in place of ferro-manganese for the purpose of recarbonizing steel at the close of either a Bessemer or Martin operation. It will be necessary in this case to keep

account of the difficulties which will be the consequence of the properties which we have described.

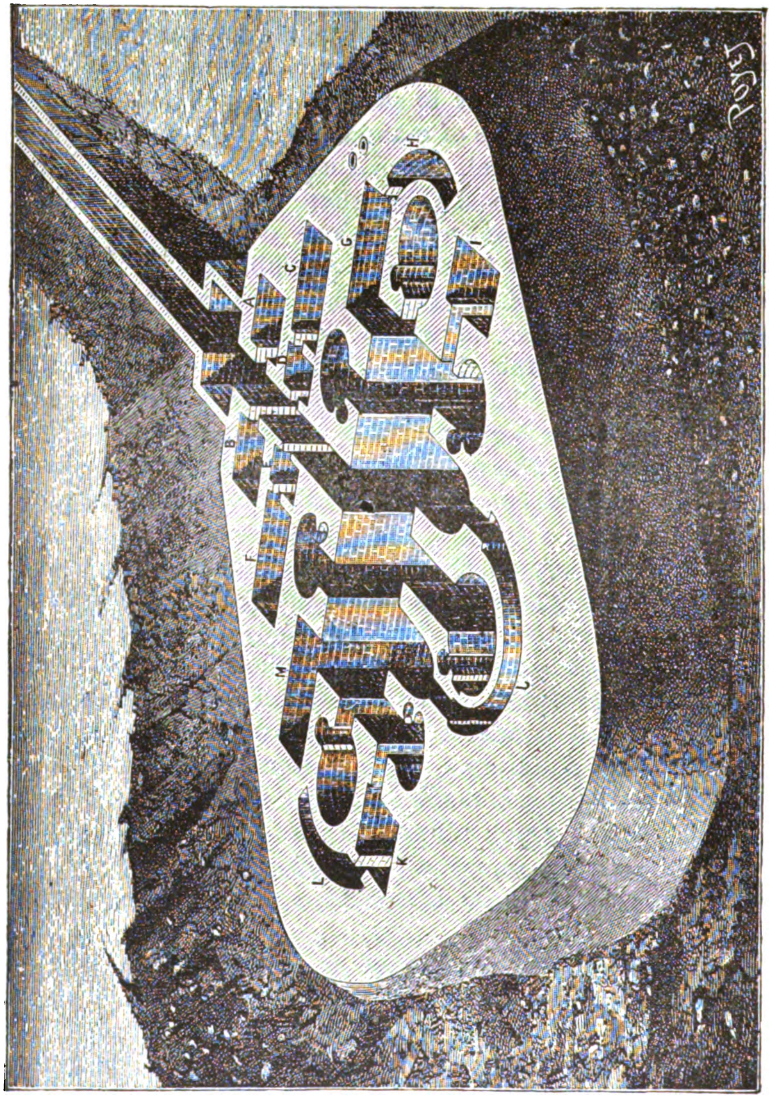


FIG. 18. Mougin Turret Fort, showing Foundations.

We regard it as very difficult to produce an extra soft steel containing much chromium, for instance, a metal that

when cast will contain from one to two per cent. of chromium, and one or two thousandths of carbon. Judging

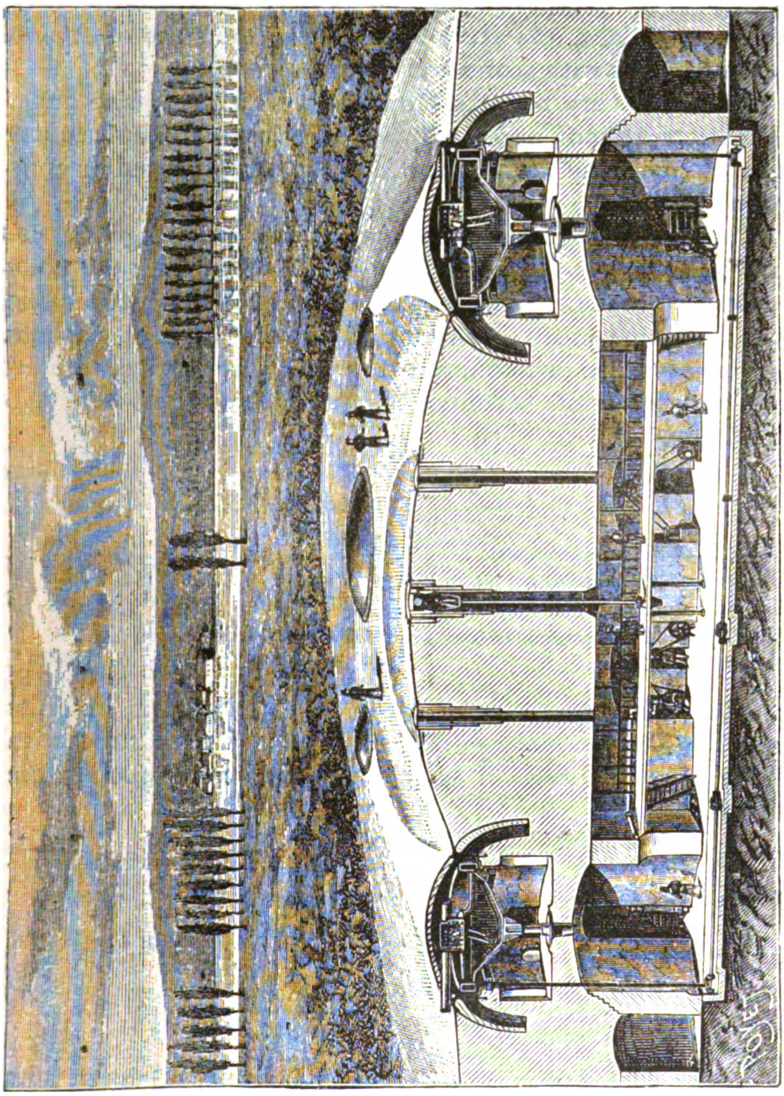


FIG. 19. Mougin Turret Fort, showing Details.

by analogy, a metal of this composition, if it is clear and sound, will have a remarkable ductility.

There is with this production a double difficulty. First, the ferro-chrome which is made is always very rich in carbon, and an alloy but little carbonized is no longer fusible at industrial temperatures and is readily oxidizable. In the second place, the steel obtained at the state of fusion becomes filled with scoria and veins on cooling.

For these very reasons, chrome steel will require most delicate treatment, and it will be exceedingly difficult to use it in the manufacture of sheeting, especially mixed or compound sheeting.

The following tests were made a few years ago in the presence of representatives from the principal railroad companies in France. Three pieces were taken from the same bar of chrome steel containing about 0·7 per cent. carbon. The pieces were turned down to nine millimetres diameter, and a length of seventy-five millimetres between the shoulders.*

	No. 1. Annealed. *kilogs.*	*No 2. Annealed.* *kilogs.*	*No. 3. Tempered in Oil and Annealed Dark Red.* *kilogs.*
Elastic limit per sq. millimetre,	40·2	43·3	140·
Ultimate tensile strength per sq. millimetre,	73·0	70·8	150·
Elongation per cent.,	17·9	21·2	6 2
Relation of the ruptured to the original section,	0·308	0·333	0·708

The following series of steels were exhibited in glass cases by Messrs. Holtzer, each classified and marked with the result of the test. I believe the tests were made at the Holtzer works.

CHROME STEEL.

No. of Test.	*Elastic Limit per Sq. Mm.*† — *kilogs.*†	*Tensile Strength per Sq. Mm.*† — *kilogs.*†	*Elongation.* — *per cent.*	*Relations of Ruptured to Original Section.*
1,	—	110·3	9·5	0·455
2,	44·7	73·5	19·5	0·37
3,	10·7	133.6	8·0	0·57
4,	45·4	76·8	18·3	0·410

* *Journal of the Iron and Steel Institute*, No. 2, 1886, pp. 770–778.

† Kilograms, one of which equals 2·2 pounds. One square millimetre equals $\frac{1}{645}$ of a square inch. Thus by multiplying the number of kilograms given by 2·2 and then by 645 we get the number of pounds per square inch.

CHROME STEEL.—*Continued.*

No. of Test.	*Elastic Limit per Sq. Mm.* — *kilogs.*	*Tensile Strength per Sq. Mm.* — *kilogs.*	*Elongation.* — *per cent.*	*Relations of Ruptured to Original Section.*
5,	83·5	95·7	13·0	0·419
6,	—	137·4	6·0	0·695
7,	39·2	65·7	22·5	0·615
8,	76·8	87·6	6·0	0·825
9,	—	149·6	0·5	1·00
10,	39·2	66·4	26·5	0·495
11,	74·8	86·2	12·2	0·70
12,	112·2	121·6	6·5	0·74
CHROME AND TUNGSTEN STEEL.				
1.	39·9	67·0	20·8	0·70
2	73·5	82·1	7·0	0·67
3.	133·6	143·5	2·5	0·94
4.	46·0	72·5	17·5	0·67
5.	86·9	96·4	6·2	0·85
6.	136·0	149·6	1·8	0·93
7.	50·8	80·6	14·5	0·76
8.	193·8	104·2	5·0	0·87
9.	133·0	148·0	—	—
TUNGSTEN STEEL.				
1,	33·4	48·2	23·7	0·245
2,	36·7	53·5	19·5	0·277
3.	47·5	58·0	17·5	0·240
4.	35·4	50·0	23·5	0·4
5.	34·1	50·0	8·2	0·94
6	—	65·4	1·0	0·412
7.	29·3	54·8	23·5	0·549
8.	63·4	82·1	10·2	0·60
9.	95·0	126·1	2·5	0·975
10.	33·4	65·4	17·0	0·67
11,	73·5	94·5	8·5	0·76
12,	—	192·0	4·5	0·96
13.	44·0	74·8	9·0	—
14,	76·8	99·0	8·3	0·73
15,	—	150·0	2·8	0·99
16,	44·0	72·8	3·5	—
17,	76·1	96·4	2·0	—
COPPER STEEL.				
1,	30·7	54·8	22·5	0·49
2,	70·1	77·5	17·5	0·41
3,	66·8	79·8	13·0	0·40
4,	46·0	59·0	18·6	0·50

COPPER STEEL.—*Continued.*

No. of Test.	Elastic Limit per Sq. Mm. — kilogs.	Tensile Strength per Sq. Mm. — kilogs.	Elongation. — per cent.	Relations of Ruptured to Original Section.
5,	100·0	122·3	6·2	0·76
6,	85·5	105·3	11·0	0·635
7,	30·7	54·8	22·5	0·49
8,	66·8	85·5	14·5	0·50
9,	—	110·0	2·0	0·97

MANGANESE AND SILICON STEEL.

1,	85·5	102·8	12·5	0·540
2,	46·9	70·7	22·5	0·454
3,	53·4	80·2	18·5	0·455
4,	118·8	126·1	10·7	0·53
5,	54·2	100·0	10·8	0·81
6,	103·4	112·3	7·8	0·69
7,	129·4	139·9	2·3	0·892
8,	46·1	63·7	22·2	0·41
9,	107·0	120·0	10·5	0·615
10,	92·2	112·2	14·2	0·50

MANGANESE STEEL.

1,	30·0	58·7	22·0	0·58
2,	76·8	102·8	12·5	0·55
3,	64·0	78·8	13·0	0·62
4,	34·6	61·6	14·0	—
5,	77·5	104·9	11·8	0·538
6,	69·4	92·2	10·0	0·54
7,	32·6	68·7	20·0	0·58
8,	84·2	108·4	8·5	0·635
9,	90·9	113·6	13·0	0·60
10,	40·1	75·5	16·0	0·645
11,	93·8	114·8	10·0	0·59
12,	86·2	99·3	11·8	0·565
13,	40·1	72·1	19·0	0·49
14,	102·8	123·5	7·5	0·69
15,	93·8	108·4	8·5	0·55
16,	109·6	124·0	8·0	0·69
17,	85·5	104·2	11·5	0·60
18,	41·4	81·3	29·0	0·74
19,	43·5	86·0	28·0	0·715
20,	37·2	96·4	41·5	0·635
21,	27·4	36·0	36·0	0·27
22,	36·7	48·2	24·5	0·275
23,	44·7	61·4	15·0	0·240
24,	33·2	67·9	14·0	0·79

MANGANESE STEEL.—*Continued.*

No. of Test.	Elastic Limit per Sq. Mm. — kilogs.	Tensile Strength per Sq. Mm. — kilogs.	Elongation. — per cent.	Relations of Ruptured to Original Section.
25,	13·0	97·8	10·5	0·578
26,	70·7	90·2	11·2	0·540
27,	31·3	64·0	21·5	0·578
28,	83·5	112·2	13·0	0·615
29,	73·5	93·8	10·5	0·54
30,	33·4	64·7	23·	0 495
31,	97·8	113·6	10·	0·615
		CARBON STEEL.		
1,	23·3	32·0	37·	0·267
2,	43·4	56·1	19·5	0·316
3,	33·4	52·8	26·5	0·465
4,	98·5	129·4	13·3	0·025
5,	67·4	92·2	12·8	0·52
6,	—	67·4	11·8	0·821
7,	65·4	99·7	5·0	0·93

[*To be continued.*]

ON SCHOOLS: WITH PARTICULAR REFERENCE TO TRADES SCHOOLS.

BY JOSEPH M. WILSON, A.M., C.E.
President of the FRANKLIN INSTITUTE.

[*Continued from vol. cxxx, p. 60.*]

Among other subjects that were still (1st November, 1888,) under consideration, the following may be of interest:

That teachers be informed that the Board do not pay so much attention to the percentage of passes obtained at the Government inspection, as to the general tone and character of the school-work.

That the number of mixed schools be increased in suitable districts, and that the staff of such mixed schools be arranged so that the number of women teachers shall not be less in proportion to the men teachers than the girls to the boys.

That in each mixed department under a master, an

appointment be made of a head assistant mistress, who shall be responsible for the teaching of needle-work to girls.

That advanced evening classes be established at the various pupil-teachers' schools, for instruction in science and drawing, commercial subjects and modern languages.

That the play-grounds attached to schools be used for the formation of clubs for hardy sports, gymnastic exercises and drill, and that the school organizations be used for the establishment of field clubs and swimming classes.

That the Chairman of the Board be asked to convene a meeting of local managers and others to consider the question of organized physical education out of school hours and to request personal help in the work.

Also, among the requests under consideration to be made for revision in the new code, may be noted; one for more freedom in choice in the selection of class subjects, so that the first class subjects need not necessarily be English; that short-hand be recognized as a specific subject; that provision be made for payment of a grant in the case of all girls of eleven years of age below Standard IV, who have received efficient instruction in cookery; that it shall be obligatory upon pupil-teachers to exhibit a knowledge of elementary science, in some form, at their annual examinations; and that application be made to the science and art department, that their syllabus be remodelled, so as to supply a greater stimulus to drawing being taken in combination with geometry and measurements, in preparation for manual work.

These recommendations, etc., are given in detail, as it is possible they may offer valuable suggestions to those interested in such matters. The whole tendency appears to be towards the encouragement of manual training, and the teaching of science, drawing and practical subjects generally.

The teachers are paid fixed salaries irrespective of the government grant earned, and the pupil-teachers are not only teachers in the schools, but are also indentured to the Board as apprentices.

There are twelve central schools for the instruction of

pupil-teachers, the seniors, or those in the third and fourth years of apprenticeship, attending these schools on two half-days and on Saturdays, and the juniors, or the first and second-year probationers and the second-year pupil-teachers and candidates, attend on part of each day and on Saturday mornings. The head teachers of their own schools are also required to exercise a strict moral supervision over their pupil-teachers; to see that, they attend regularly and punctually the pupil-teachers' schools, and that they give proper attention to the preparation of their lessons, and to their private studies; to correct their notes of lessons; to direct and supervise their methods of teaching; and to examine, sign and date, each week, the pupil-teachers' report book, and to see that it is properly kept.

The Board considers that it would be useless to teach children the mechanical art of reading unless they were inspired with a love for reading, and in order to encourage this it has provided lending libraries of carefully selected books for the children. To encourage thrift among the scholars, the question of penny banks in the board-schools has been taken into consideration, and arrangements have been made for establishing such banks, wherever practicable, in both boys' and girls' departments. Some are already in working condition.

Certificates are given in the senior departments to all Standard children who have passed the Government examination in all the elementary subjects, and reward cards, prizes and medals are given for regular and punctual attendance. The National Health Society has also provided funds for a certain number of prizes to girls, after examination in the laws of health and domestic economy, and private benefactors have provided sums of money for the purpose of founding scholarships and exhibitions, intended to connect public elementary schools of the metropolis with schools of a higher grade.

There are also a number of other scholarships of various kinds, and all of these act as an incentive to study, and afford those who gain them great advantages in obtaining a higher education.

EVENING CLASSES.

Previously to the year 1882, there were no evening classes, excepting some which were opened as an experiment and afterwards closed, and some which were not under the control of the Board, but in the autumn of that year, the Board, feeling that there was a growing necessity for elementary instruction in the evening, opened elementary evening classes in eighty-three schools, conducting them in accordance with the elementary education acts and government code and giving the same instruction as in the day-schools. To show the progress of these classes it may be stated that in 1882–83 the number of pupils admitted was 9,064, giving an average attendance of 1,707, and 1887–88 the number admitted was 16,320, with an average attendance of 5,805. These classes are in session only during the winter months, the first term being from the end of September to the end of the week preceding Christmas week, and the second from the second week in January to the end of the week preceding that in which Good Friday falls. The classes are generally held on three evenings in the week between the hours of 7.30 and 9.30, and the two sexes are not taught in the same building at the same time. The fee (except in a few cases) is three pence per week or two shillings a term.

Young persons over fourteen years of age, and children who are not under legal obligations to attend day-schools, may attend the evening classes, and with a view of inducing them to commence doing so as soon as possible after they discontinue day-school attendance, there is kept in every day-school a book, entitled *Old Scholars' Book*, in which each scholar who becomes exempt from legal attendance at day-schools is, when leaving such school, requested to enter his or her name, address, Standard last passed, date of leaving school, and desire as to attending evening classes. It is the duty of the head teacher to see that these entries are properly made and to urge attendance on the scholar. Immediately after, and frequently during the session, invitations are sent out to those on these lists, asking them to join the classes.

In order to also encourage the pupils to attend regularly

and to sit at the government examinations, prizes of books are given to pupils who make attendances at the rate of eighty-five per cent. or more, of the times that the classes are open during the session, who sit at the government examination, and who conduct themselves satisfactorily. Certificates are awarded to those who pass in two or more subjects at the examination.

Special classes for instruction in French are opened in connection with the elementary classes where twelve or more pupils present themselves, and special fees are charged. Special classes in practical cookery were also opened as an experiment in 1888 at four centres in different parts of the metropolis, giving two hours' instruction on one evening per week, at a fee of one penny per lesson, but the experiment was not a success, owing, it is believed, to the unfavorable conditions of the code of the Educational Department, that only pupils belonging to the elementary classes could attend these special classes; that the pupils to earn a grant must make a certain number of attendances at both kinds of classes, and that the special classes should be held on an evening when the elementary classes did not meet; conditions that necessitated absence of the pupils from their homes on four evenings in the week.

Recreative evening classes for instruction in recreative and practical subjects have been introduced in answer to a memorial request from the London Trades Council, with excellent results. Such matters are taken up as music, drill, gymnastics, singing, drawing, modelling, wood-carving, needle-work, chemistry, physiology, electricity, geography, history, etc., oral teaching and object lessons, illustrated with the magic lantern. This work is carried on under the auspices of the "Recreative Evening-Schools Association," of which H. R. H. the Princess Louise is President. Only pupils in the elementary classes are allowed to attend the recreative classes. The effect has been to largely increase the attendance at the elementary classes and to bring about a close connection between the two.

In addition to the establishment of elementary classes, considerable work has been done with advanced classes for

instruction in the subjects recognized by the science and art department and the city and guilds of London Technical Institute, also in book-keeping, short-hand, singing and the preparation of candidates for civil service. Only responsible teachers of elementary classes are allowed to conduct the advanced classes.

The following table may be of interest, as showing the attendance at the classes for the session commencing at the end of September, 1887, and ending at Easter, 1888, in the cases of short-hand, singing and civil-service classes, and at the May examinations in the cases of the science and art classes. All the subjects were taught in connection with the science and art department, except carpentry and plumbing, which were taught in connection with the city and guilds of London Technical Institute, the subject taught in classes for the preparation of candidates for the civil-service and book-keeping, German and short-hand.

Subject.	Number on the Roll.			Average Attendance.		
	Male Pupils.	Female Pupils.	Total.	Male Pupils.	Female Pupils.	Total.
Agriculture,	13	36	49	10	28	38
Animal physiology,	15	19	34	13	16	29
Art,	33	51	84	23	34	57
Book-keeping,	1	11	12	1	10	11
Botany,	10	—	10	7	—	7
Building construction,	102	—	102	58	—	58
Carpentry,	10	—	10	6	—	6
Chemistry, inorganic,	90	—	90	66	—	66
" organic,	40	—	40	22	—	22
" theoretical and practical,	15	1	16	9	1	10
Civil service,	16	2	18	14	1	15
Geometry, P., P. and S.,	159	—	159	107	—	107
German,	12	8	20	8	5	13
Hygiene,	9	3	12	7	2	9
Machine construction,	130	—	130	106	—	106
Magnetism and electricity,	225	6	231	170	3	173
Mathematics,	108	2	110	77	2	79
Mechanics,	81	1	82	58	1	59
Physiography,	87	32	119	68	25	93
Plumbing,	16	—	16	9	—	9
Short-hand,	850	39	889	690	37	727
Sound, light and heat,	79	—	79	55	—	55
Steam,	20	—	20	16	—	16
Total,	2,121	211	2,332	1,600	165	1 765

At the examinations held by the Science and Art Department and by the city and guilds of London Technical Institute, 967 pupils were presented, of which 163 passed in the first class, 464 passed in the second and 340 failed.

Special committees of local managers, composed of ladies and gentlemen residing in the locality of the classes, assist the committee in their work, and one of the managers cts as honorary correspondent.

The recreative and advanced classes involve no extra expenditure on the part of the Board, a Provisional Com mittee, of which the Archbishop of Canterbury is President, providing the necessary funds, apparatus, etc. The cost of conducting the elementary classes was not quite eleven shillings per pupil.

Matters in connection with the Industrial School Committee (ragged schools, etc.), and the other committees are not pertinent to the present inquiry.

SLÖJD.

Mention has been made of the "Slöjd" system of handicraft in connection with the London board-school.

Slöjd instruction in its great development is due to Sweden, but the original realization of the idea belongs to Finland, through Uno Cygnaeus, the founder of its public-school system, and "the statute of 1866, respecting the organization of this school system in the Grand Duchy of Finland, drawn up chiefly according to his recommendations, is certainly the first common-school ordinance which adopts *technical handwork* as an obligatory exercise in seminaries, and Slöjd for boys in the country schools."

I am indebted for considerable information on the Slöjd schools of Sweden and Norway to a report on "Handwork Instruction in Sweden," by Prof. John M. Ordway, of the Massachusetts Institute of Technology, published in the *Forty-sixth Annual Report of the Board of Education*, Boston, Mass., and republished in the *Parliamentary Report of the Royal Commissioners on Technical Instruction*, London, 1884. In this report are valuable extracts from a publication, entitled *Work Schools*, by a Norwegian school inspector, H. K. Kjennerud (Kristiania, 1882). I have abstracted freely from this paper, only regretting that it is not of a later date.

Slöjd is a word derived from the old Norse language,

and is peculiarly Swedish in its present signification, with a meaning very comprehensive, but very difficult to define. It implies "work with the hands and with simple tools." The Swedish Slöjd schools have been in existence only about nineteen or twenty years, omitting consideration of the Willinsk school in Göteborg and the Prince Carl's Institute at Gâlö, which are not schools in the ordinary sense, but institutions established as homes for children. These schools have increased very rapidly in Sweden until it is becoming very general in that country to combine the Slöjd instruction with that in the common schools, and to employ the school-teachers themselves to teach it.

This teaching, however, is not limited to schools for children, and one will find in Sweden, here and there, schools and courses of Slöjd instruction for grown persons. There is a Slöjd seminary at Nääs, two Swedish miles from Göteborg, founded and endowed by Herr Abrahamson, as a private institution to supply the demand for teachers. The superintendent of this seminary is Herr Salomon, and it was under him that the teachers forming the Slöjd Union in England, of which he is President, were trained, the certificate of efficiency from Nääs being a requirement for membership in that Union. The Union of Slöjd Teachers in England has for its objects the mutual help of the members in all matters relating to Slöjd and the promulgation from time to time of the principles of that system, by means of pamphlets and in other ways, the members pledging themselves to adhere to the educational principles of Nääs, in order to maintain a high standard of efficiency.

The work in the Nääs Slöjd Seminary is carried on according to a series of models arranged in systematic order, the catalogue containing 216 numbers and divided into the following sections: Models, full size; polished work, wood-carvings, models on a smaller scale. Seminary students are capable of working all the numbers. Objects coming under the denomination of toys are particularly excluded.

The fundamental principles of the instruction given in this school are well explained by a circular distributed by the Slöjd Union, of which the following is a copy:

A.—AIM OF THE INSTRUCTION.

Whilst the elementary schools prepare the children *indirectly* for life, the chief aim of the teaching of Slöjd is to give the pupils formal instruction; that is, to develop their mental and physical powers. It has also for its material and practical aim the acquisition of general dexterity of hand.

This formal education which Slöjd has in view aims principally at:

Instilling a taste for and love of work in general.

Inspiring respect for rough, honest bodily labor.

Training in habits of order, exactness, cleanliness and neatness.

Accustoming to attention, industry and perseverance.

Promoting the development of the physical powers.

Training the eye and sense of form.

B.—THE METHOD AND MEANS OF INSTRUCTION.

I.—General Principles.

Attendance at Slöjd instruction should be voluntarily on the part of the pupils. In order to ensure this the work must fulfil the following conditions:

(1) It must be useful.

(2) It must not require fatiguing preparatory exercises in the use of the various tools.

(3) It must afford variety.

(4) It must be capable of being carried out by the pupils themselves.

(5) It must be *real* work, not play.

(6) It must not be so-called knick-knacks; that is, articles of luxury.

(7) It must become the property of the pupil.

(8) It must correspond with the capabilities of the pupils.

(9) It must be of such a nature that it can be completed with exactness.

(10) It must admit of neatness and cleanliness.

(11) It must exercise the thinking powers and not be purely mechanical.

(12) It must strengthen and develop the bodily powers.

(13) It must assist in developing the sense of form.

(14) It must allow of the use of numerous manipulations and various tools.

II.—The Teacher.

(1) The instruction must be given by a trained teacher, if possible by the same teacher who instructs in intellectual subjects.

(2) The teacher should conduct, superintend and control the work; but guard against directly putting his hand to it.

III.—The Age of the Pupil.

In order to follow with advantage the course of instruction, the pupil ought to have reached that stage of development usually attained at the age of eleven.

IV.—Branches of Instruction.

The simultaneous employment of several different kinds of Slöjd acts detrimentally for the following reasons:

Already a sufficient number of subjects are taught in the school and every different branch of Slöjd is a subject in itself.

The time to be devoted to this work is short and limited.

By different kinds of work the interest of the pupils would be easily diverted, therefore the instruction in Slöjd should be confined to one branch.

For the above-mentioned standard of age *wood-slöjd* is the most suitable. It includes carpentry, turnery and wood-carving.

Slöjd-carpentry differs from trade-carpentry, in the following respects:

(1) As to the character of the objects made: in general the objects are smaller than those made in the trade.

(2) The tools which are used: for instance, the knife is the most important tool in wood-slöjd—in carpentry, it is rarely used.

(3) The method of working: in trade-carpentry, there is division of labor—in Slöjd, none whatever.

Turnery may be taken as a different branch of instruction, and as such be quite well separated from wood-slöjd.

V.—The Number of Pupils.

Individual instruction is generally advisable--this is especially the case with Slöjd, which, on fundamental and practical grounds, cannot be taught as a class subject; therefore the number of pupils taught by one teacher must be limited.

VI.—The Models.

In order to make the instruction as intuitive as possible, models ought to be used in preference to drawings. The form should be sketched either directly, by placing the model on the piece of wood, or by means of a diagram drawn with ruler and compass on the wood.

In arranging a series of models, the following points must be observed:

A.—*As to the Choice of the Models.*

(1) All articles of luxury are to be excluded.

(2) The objects made are to be capable of being used at home.

(3) They are to be such objects that the pupils can finish them without any help.

(4) They are to be such objects as can be made entirely of wood.

(5) The work is not to be polished.

(6) As little material as possible is to be used.

(7) The pupils are to learn to work both in hard and soft woods.

(8) Turnery and carving are to be used as little as possible.

(9) The models are to develop the pupil's sense of form and beauty.

In order to attain this, the series must include a number of examples of form, such as spoons, ladles and other curved objects which are suitable for execution by the hand *alone*, guided by the eye.

(10) The whole series must be so arranged as to teach the pupils the use of the necessary tools, and to know and carry out all the most important manipulations connected with wood.

B.—*As to the Arrangement of the Models.*

(1) The series must progress without break from the easy to the difficult, from the simple to the complex.

(2) There must be a refreshing variety.

(3) The models must follow in such progressive order that by means of the preceding ones, the pupils may obtain the necessary aptitude to make the following ones without direct help.

(4) The models must be so graduated that at every stage the pupil is able to make an exact copy, not merely an approximate one.

(5) In making the first models only a small number of tools must be used; as the work progresses the number of tools and manipulations should gradually increase.

(6) At first the knife, as the fundamental tool, should be mostly used.

(7) Rather hard woods should generally be used for the first models.

(8) At the beginning of the series the models should be capable of being quickly executed, and gradually models which require a longer time should be given.

Mr. J. S. Thornton, of Victoria Park School, Manchester, Chairman of the first general meeting of the Union of Slöjd Teachers, in his opening address said (I quote only extracts from this address) that education in England is too one-sided and literary; that it is more fitted to make clerks than to form capable craftsmen; that what was needed was something that would combine the exact training of the eye and hand, which drawing affords, with the activity, the freedom and exhilaration of movement which are characteristic of the national games. And that this something was found in the use of elementary tools, the absence of which from the school curriculum has been regretted by men as wide

apart as Luther, Locke and Rousseau. Many teachers are more than half convinced—those who have been to Nääs are entirely convinced—that a cunningly devised instrument, ready to the schoolmaster's hand, has there been forged, which will make good the defects that have so long been calling for a remedy. It is believed that it is Slöjd, rather than what is usually known by the term manual training, that will enable the required result to be brought about in the ordinary schools. In this connection, it is of the very essence of Nääs Slöjd that it be taught by the form master, *properly trained*, and not by the village carpenter or other artisan, however intelligent.

The group of exercises, of which the Slöjd models are the embodiment, are a noteworthy example of very fine graduation. The various processes which are necessary to produce all the models of a series, have been subjected to careful analysis; and then the elementary manipulations, so obtained, are by a corresponding synthesis grouped together, in a varying order, to form model after model, but in such a way that the ratio of the new elements to the old, always a small one, shall actually diminish as the work proceeds. Nowhere out of Euclid does any subject proceed with such an ordered march. The ideal is that no single model, however complex, shall give more trouble to the advanced student than the simplest one does to the beginner.

Slöjd is educational rather than technical. Sir John Lubbock tells us there are two theories with regard to manual training: "The one treats the school as subordinate to the workshop; the other takes the workshop and makes it a part of the school. The one seeks to make a workman, the other to train up a man." Schoolmasters are often urged, and never more so than now, to let their pupils begin to specialize at too early an age. And it might be thought that in advancing the use of tools as part of the ordinary school curriculum, we were yielding to this pressure. It is not so. The Nääs wood-slöjd, in its principles and details, has for its direct aim the development of all a child's power, physical, mental, moral. It paves the way for technical instruction in after years, but is no part of technical instruc-

tion proper. It is intended to give general manual dexterity, and prepares for no special trade or profession.

In the Slöjd-room, complete articles are made from the very commencement; whereas, in most other kinds of manual training, the young pupil is for long periods kept at mere exercises which seem to him to lead to nothing. There can hardly be a question which of the two methods is the more likely to call forth the pupil's interest.

These extracts from Mr. Thornton's address are sufficient to show what Slöjd is expected to accomplish. An address made at the same meeting by Miss Teskey, of Sydenham College for Ladies, gives good evidence that this method of teaching is applicable to girls as well as boys. Miss Teskey stated that her attention had been first drawn to the subject of Slöjd in 1887, and that she took up the study of it principally with the view of introducing it for the pupils in the school with which she was associated, as a means of active bodily recreation. She had long noticed with concern how girls spent their spare time and holidays in reading, writing, drawing, painting and needle-work, the only active exercise they took by way of recreation being dancing. In summer, of course, they had plenty of out-door exercise, but in winter they were greatly in need of some *interesting active occupation* to counteract this continual sitting and stooping over books, drawing, etc. She soon became convinced that Slöjd afforded interesting and certainly active bodily work, and that it might be made a most important factor in the development of the physical powers; therefore, on this account alone, would be invaluable to girls of the upper classes. But most of all she was impressed with the educational value of Slöjd in the moral training of the girls. Unconsciously they learn self-reliance, accuracy, perseverance—all qualities which need very especial cultivation in their case.

Miss Teskey began in October, 1887, with a class of nineteen or twenty girls, varying in age from eleven to eighteen. The attendance was voluntary and came out of the recreation time. The work was a gratifying success; the interest, which was very great at the beginning, was maintained

throughout the course, and the advent of each fresh model was hailed with delight, while the greatest anxiety was evinced for the passing of a model. The models were carefully examined when finished and if not up to the Näås standard, were rejected. The work was remarkably good, not more than five or six models failing to pass, and there were no accidents from the use of the tools.

Miss Teskey stated that Slöjd fulfilled all that it proposed. It developed the pupils physically and mentally, the physical advantage being soon apparent in individual cases as well as in the whole class, and as to mental training, it roused the indolent mind by giving it something definite, tangible to think about and do, and excited a taste for the love of work. This was shown in a very marked manner in several cases, and some who before would sit idly over their lessons for an hour or two, quite unable to think or to concentrate their attention, got through their lessons briskly and cheerfully in order to have time to spare for Slöjd. Any teacher of Slöjd, says Miss Teskey, would be soon convinced of its great power as a means of training the observation and cultivating the eye and sense of form.

The Slöjd Association of Great Britain and Ireland is another organization of the same type, having for its object to make Slöjd known to educators and the public generally, and to unite all those who are interested in its promotion; to found a Slöjd training institute for teachers, which shall also serve as a centre where information on Slöjd work and principles can be obtained and become the headquarters for branches throughout the country; to endeavor to make Slöjd *national* in character by adapting the practical work to English habits and requirements, while adhering to its principles, which are equally true for all countries; and to establish a Slöjd register in which shall be entered the names of the teachers and schools where Slöjd work has been inspected and approved by the Association.

The President of this Association states that "there is a growing feeling of discontent with the present system of national education, and all who have studied the subject are agreed that it is one-sided, mechanical and too exclusively

literary." "Most thinkers are likewise agreed (though they differ as to the means) that the defect lies in the neglect of physical and manual training." "For young children this is already provided by the kindergarten." "To draw out all the faculties, to satisfy the active and constructive instincts of children, to arouse their interest and stimulate their curiosity—such is the method of Froebel." "The Slöjd system is based on the same principles, and it carries on the work of the kindergarten in a form suited to the growing physique and maturer powers of older children."

In the Swedish schools the time devoted to Slöjd appears to be six to eight hours per week, and the number of hours instruction which each boy receives depends upon the number of boys in the school from eleven to fourteen years of age, the classes being limited to about sixteen at a time. The subjects taught are joinery, turning, simple carving, basket-work, and in some cases, blacksmithing, wire-working, shoemaking, tin-plate working, painting and bookbinding. Courses for the improvement of Slöjd teachers are generally held in the summer vacation.

The children do not appear to be by any means confined to working according to a system of models, and there are instances where they are kept at the same kind of work for a long time, really doing a manufacturing business in such things as apparatus for use in the common schools, etc. Schools have the privilege of purchasing models from the Nääs Slöjd Seminary at a low price.

In one of the schools it is specified that the instruction shall be such that the pupils will acquire dexterity in making articles needed and used by working people, rakes, spades, axe-handles, etc. The boys are sometimes given what they make, and at other times have half the value of their work, or may buy it at half price, while there are cases where the productions are kept by schools. Poor children are allowed their shoemaking free, while those who have the means, pay for the materials, etc. The practice differs in different localities.

In the Upsala län, a Slöjd Committee makes arrangements for inspecting the work-schools of the län. It assists

the schools by contributions of money, certain conditions being fulfilled, arranges to lend models and sometimes tools. There is a store in Upsala for the sale of domestic industrial products, and the products exhibited there, comprising men's and women's work, useful objects and articles of luxury in infinite variety, show that this industry is in an advanced state. Such agencies also exist in other parts of Sweden, and are really a necessity to make domestic industry a success. That kind of aid is now extended to women in our own city by means of the Philadelphia Exchange for Women's Work.

At Göteborg, Slöjd is obligatory for the older classes in all the common schools, where, in 1880, about 1,400 children were taught. Here the working time of the pupils is ten hours per week. The school is considered as preparatory for hand-work, and the teachers are without exception hand-workers. From one to three months are spent in each department, and the remaining time, when possible, is devoted to that work for which the pupil shows the greatest interest and aptitude, the aim being not to acquire general dexterity as much as expertness in some special direction.

Pupils receive a profit from their work, and at examinations, premiums are given to the most skilful, if also satisfactory in their school studies.

The Slöjd schools of Göteborg have attracted much attention on account of the remarkable skill with which they are managed, but there appears to be a question "whether in this management, there is not a want of a right pedagogic view, and whether the work-schools have not come to run in the service of the trades and in a track which they should not go."

In Wernersborg, Slöjd has been made compulsory in the common schools since 1872. Tailoring is one of the branches of instruction, but boys do not as a rule take an inclination to this. The workshops are small and the pupils are so divided up that there will not be more than eight or ten in a class. Orders are taken by the school, and auction sales are made of things worked up.

In Norway, the principal schools are at Kristiania and

Fredriksstad. The latter is exceptional in that it is maintained by the common-school funds. Hardly anywhere in Norway have greater sacrifices been made for hand-work construction than in Fredrikshald. The Fredrikshald Slöjd Union was formed in 1874, with the object of laboring for the advancement of domestic work and habits of industry. A work-school was opened immediately after New Year, 1876, for forty-eight pupils, soon increasing to 130. Gifts of subscribers and others, also contributions from the city, all aided in helping the work, and, in 1882, the school moved into a new building, with largely increased classes, and in addition, a work-school for boys was established in one of the suburbs of the city. Some of the pupils are common-school boys and some are from the Latin school. The regular term is from the first of September to the end of April, but Latin school pupils can begin on the first of October. It is the duty of the teacher to instruct seven hours in the day and in addition, to spend six hours a week in keeping the tools in repair, etc. At the date of the information at my disposal, concerning this school (1882), there were, besides the regular teacher, who was very skilful as a carver and could in addition give instruction in basket-work, brush-making, painting and bookbinding, also five teachers by the hour: one shoemaker for eighteen hours, one tailor for six hours, one bookbinder for eight hours, and one journeyman joiner for six hours a week.

Besides the regular work of the school there are, every year, extra courses. Women and girls are instructed in wood-carving and bookbinding; the manufacture of wooden shoes is taught and also the making of various simple articles of furniture.

In the department for joinery, each work-bench is provided with a drawer containing three chisels, one rasp, one file, one rule, two squares, one brad-awl and one draw-knife. In addition, every bench has a small jointer plane, a jack plane, a smoothing plane, a saw, a mallet and a hammer. There are other tools which are used by the pupils in common.

From New Year, 1881, work has been carried on according

to a systematic collection of models, the idea being derived from the Nääs Slöjd Seminary, but the order of work differs in many important points from that of Nääs. The list of models is not nearly as large, but there are generally included from two to six different articles under one number of which the pupil, according to circumstances, has to make one or all. The reason for this arrangement is partly that if each number had only one article placed to its credit, so many of a kind would be made as to render them unsalable, and partly to give the pupil a chance of making a choice.

The Nääs system begins with the use of a knife, while at Fredrikshald the pupils commence with the use of the saw, the plane and the file. Whittling exercises are taken at a certain time in the year, several weeks in succession, by all classes in joinery at the same time.

At Nääs, pieces of turning and simple carving are placed in the list, while here the turning work is kept separate, and it is made voluntary on the part of the pupils. A very few pieces of carving are made by requirement, but the student can devote himself more exclusively to wood-carving, if he wishes, after having reached a certain stage in the course.

After trying tailor work for two years it was decided to give it up, as it was not a success. Painting (house and cabinet painting) is being taught successfully and also bookbinding. Instruction in drawing was commenced in the autumn of 1881, with three hours' instruction weekly, after the Stuhlmann method, which is in general use in Sweden in all technical and other public schools, where such instruction is given. This method has the advantage of "making the first trivial exercises interesting to the pupils, who have immediate satisfaction of forming very pretty figures and patterns, without its being difficult, or departing from the common pedagogic principle of going from the easier to the more difficult." "The drawing is done first in a book ruled in squares, and next in a dotted one according to the teacher's sketch on a dotted blackboard, painted for this method." "Further on, after figures in straight and curved lines have been drawn, with the help

of lines and points in the two books, there are commonly used drawing books for geometrical figures according to the teacher's sketch on the black-board, with the use of the Stuhlmann plates." "Then follow other figures, and finally, drawing from plaster, objects in *bas-relief*, blocks without shading, plaster figures in *alto-relievo*, and blocks with shading."

In reference to the children, the methods of ordinary schools are carried out as far as possible; regard is had to good behavior and every endeavor is made to inculcate habits of courtesy, neatness and order.

It was found, as a rule, that only the younger boys came to school and that they left it when reaching an age at which they would derive the most profit from their instruction. The principal reason seemed to be that older boys were more useful at home and could often earn wages for work, also that they disliked the restraint of the school. To encourage a longer attendance of the pupils, it was decided, instead of giving them premiums as rewards for diligence, constant attendance and good conduct, to credit them (in those branches of work, in which the school furnishes materials and keeps the products) with wages, which are regularly entered in a work-book and are not paid out until they leave the school, after having been for a certain time constant pupils. These wages do not, as a rule, exceed half the value of the work, and they depend on its salability, but that work which is done without the teacher's aid receives the highest pay. The work is judged in the pupil's presence by inspectors and teachers jointly, and any observed inaccuracy is pointed out on this occasion. When the pupil leaves school, instead of money, a savings-bank pass-book is given him, with encouragement to use it for future savings. It seems to be the opinion that the school will be more highly esteemed and more constantly attended if there is fixed a fee, ever so small, for instruction, and very small charges are therefore made. This enrolment fee has served to do away with the inconvenience of having a great many report themselves, attend a few time, and finally disappear.

[*To be continued.*]

THE OXIDATION OF SULPHIDES BY MEANS OF THE ELECTRIC CURRENT.

BY EDGAR F. SMITH.

[*Read at the Stated Meeting of the Chemical Section, June 17, 1890.*]

In the Proceedings of the Chemical Section of the FRANKLIN INSTITUTE, **1**, 52, and the *Berichte* **22**, 1019, a preliminary report was published, describing a rapid method for the conversion of sulphur into sulphuric acid through the agency of the electric current. It was there demonstrated that the sulphur in the mineral chalcopyrite, for example, was completely oxidized to sulphuric acid in ten minutes, and that the oxides Fe_2O_3, CuO, etc., were eliminated from the analysis, so that the barium sulphate finally weighed was perfectly white in appearance, and not contaminated with the impurities usually accompanying it when precipitated from solutions containing much iron, etc.

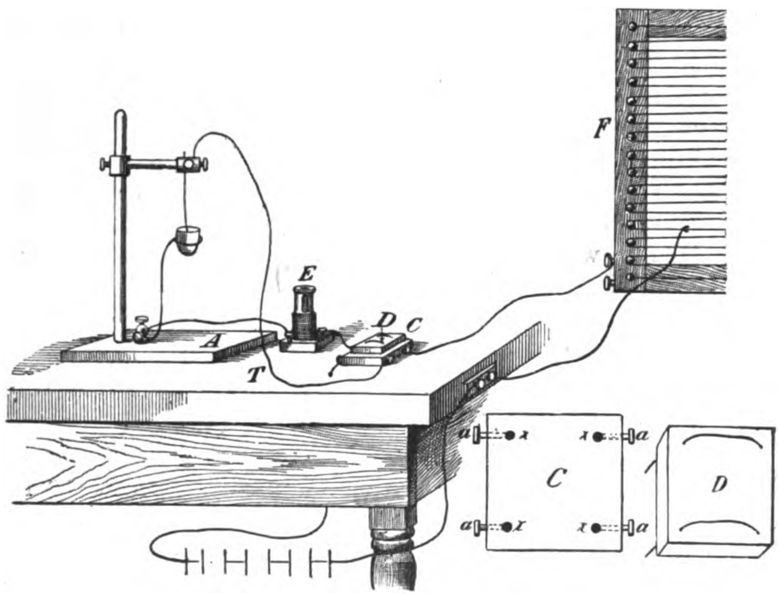
To give a better idea of the mode of carrying out an oxidation of this description, the apparatus used for this purpose will be first outlined.

T represents a table upon which stands *A*, an ordinary filter-stand, in the base of which is fixed a binding screw holding in position a heavy copper wire bent as seen in the sketch, and intended to carry the nickel crucible in which the oxidation occurs. The arm of the filter-stand has attached to it a binding screw holding a heavy platinum wire, as well as the copper wire generally in connection with the anode of the battery. *E* is a Kohlrausch ampèremeter, registering ampères and half ampères; this is in connection with *C*, a block of wood screwed or nailed to the table. There are four depressions (*x*) in *C* containing a few drops of mercury, in contact with the binding screws (*a*). *D* is the movable top of *C*; the wires crossing it project on the under side and rest in the mercury cups (*x*). When *D* is so arranged that the wires on its upper face run in the direction of the

dart, the ↑ crucible becomes the anode of the battery, whereas if they have a horizontal position, ⟶ the crucible is the cathode.

F is a resistance frame, consisting of about 500 feet of common iron wire arranged upon a light wooden parallelogram. It should always be in the circuit.

The movable cap *D* is necessary and important. It enables the operator to change the poles quickly—to reverse the current at a moment's notice. In the oxidations to be described later on, this was frequently necessary, chiefly



because when the crucible served as cathode in many of the decompositions there often occurred a considerable deposition of metal upon its sides, and in the act of separating this metal enclosed undecomposed material and withdrew it from the field of oxidation. In such cases, by making the crucible the anode, as above indicated, the mineral matter will be liberated, and upon coming in contact with a large oxidizing surface, all the sulphur contained in it will be converted into sulphuric acid. The crucible should always be covered during the oxidation.

OXIDATION OF THE SULPHUR IN SULPHIDES.

In the oxidations given later, nickel crucibles 1¼ inches high and 1⅜ inches wide were used; but a more advantageous form, one which should always be employed when more than 0·15 gram of material is used, would measure 2 inches in length and 1½ inches in width. In such a vessel, place 25–30 grams of pure potassium hydroxide (not sodium hydroxide), and warm the same until the excess of moisture is expelled. Bring the weighed sulphide into the crucible, connect the latter with the copper wire shown in the sketch, and lower the platinum wire so that it extends a short distance below the surface of the molten mass. The current is then made to pass by bringing a metallic cup, connected with one pole of the battery, in contact with one of the wires of the resistance frame *F*. The sulphur will be completely oxidized in from ten to twenty minutes. Interrupt the current, allow the crucible and contents to cool, then place the same in water. In a few minutes, all but the insoluble oxides will have dissolved. Filter, acidulate the warm filtrate with hydrochloric acid, and precipitate the sulphuric acid in the usual manner. If, upon adding acid to the alkaline solution the latter becomes turbid, from separated sulphur, it is an indication that the oxidation was incomplete. Observe closely whether sulphur dioxide is liberated even when the liquid remains clear. Never omit the examination of the residue remaining on the filter, after the alkaline solution has been filtered. The caustic alkali must always be tested for sulphur before using it in this work. It is well to estimate the impurities in the alkali and deduct them, in each determination, from the barium sulphate found.

To ascertain to what extent this method could be applied in oxidizing sulphur, the following minerals, representing all the various classes of natural sulphides, were subjected to experiment:

SPHALERITE (ZnS).

No difficulty was experienced in oxidizing the sulphur of this mineral. A current of one ampère (= 10·45 cc. electro-

lytic gas per minute) was amply sufficient for the purpose. When the mineral was added to the melted caustic potash and the current applied, the mass assumed a muddy appearance, which it retained for ten minutes when it became white and froth-like. It was discovered, by experiment, that this appearance indicated the complete oxidation of the sulphur.

(I) 0·1195 gram mineral,	20 grams alkali,	1 ampère	(time,	20 minutes),	gave	32·97 per cent. S.
(II) 0·1025 "	"	"	"	"	"	32·96 "
(III) 0·1180 "	"	"	"	10	"	32·80 "

By oxidizing the sulphur in a fourth portion with nitric acid and potassium chlorate, 32·90 per cent. sulphur was obtained.

A specimen of Joplin (Mo.) blende gave 32·60 per cent. and 32·80 per cent. S. by the nitric acid method, while by the electrolytic method 32·90 per cent. S. was found.

An impure sphalerite, locality unknown, in which there was considerable gangue and other admixtures, gave 29·8 per cent. S. when oxidized with nitric acid, and when acted upon in alkaline solution by a current giving one ampère of electrolytic gas per minute, the sulphur found was:

(I)	29·23	per cent.	S.
(II)	29·45	"	"
(III)	29·68	"	"
(IV)	29·67	"	"
(V)	29·90	"	"
(VI)	29·58	"	"

CINNABAR (HgS).

Very pure material was employed in this oxidation. Several trials were required, in order to learn the proper conditions for successful working. The tendency of this mineral, when finely divided, was to collect in lumps, which appeared to rise and fall in the alkaline solution; in order to bring every particle of material within the field of oxidation the current was reversed every few minutes. By doing this the sulphur was completely oxidized in twenty minutes or even in less time. If the precaution just mentioned with reference to the reversal of the current be not heeded more time will be required for complete oxidation and even

then it will be doubtful whether the sulphur is fully converted into sulphuric acid. Twenty-five grams of caustic alkali were used in each experiment with this mineral.

0·1089 gram cinnabar gave 13·82 per cent. S., while the required percentage is 13·79.

A current of two ampères per minute was used.

GALENITE (PbS).

There is no difficulty in oxidizing this mineral. The same quantity of alkali and the same current strength were employed here as in the mineral immediately preceding:

(I) 0·1093 gram galenite gave 14·30 per cent. S.
(II) 0·1092 " " 14·60 " "

Another portion in which the sulphur was oxidized by heating the mineral in a current of chlorine gave 14·30 per cent. S.

ARGENTITE (Ag_2S).

No difficulty was encountered in oxidizing this mineral. The decomposition was made with conditions analogous to those already described. Silver did not pass into the alkaline solution, so that when the sulphuric acid was precipitated, barium chloride was employed as usual. The specimen analyzed being exceedingly pure, it was not thought necessary to determine the sulphur by any other method. None of it remained unoxidized:

0·1032 gram argentite gave 13·04 per cent. S; required 12·90 per cent. S.

CHALCOCITE (Cu_2S).

Thus far this mineral has resisted all efforts to convert its sulphur into sulphuric acid. Repeated attempts have been made, but not more than half of the sulphur contained in the mineral was oxidized, notwithstanding the current was very much increased in each trial. Since some time may elapse before another opportunity offers itself to continue experimentation with this mineral, it need only be stated that a modification of the usual method will be tried upon it. The copper and sulphur are evidently in very intimate union.

MOLYBDENITE (MoS_2).

The sulphur in this mineral is given up readily to the oxidizing influence of the current. One annoying feature is that the fine mineral particles are so very light that they are apt to be carried up and adhere to the cover crystal. In this oxidation the poles should be repeatedly reversed. The result given below is from a sample that contained much quartz, etc. The residue, however, gave not a trace of sulphur when tested for it.

0·1045 gram mineral gave 0·2785 $BaSO_4$ = 36·60 per cent. S.

STIBNITE (Sb_2S_3).

While a current of two ampères was employed in this oxidation, the sulphur can be completely changed to sulphuric acid with one ampère. Three trials proved this conclusively.

0·1095 gram mineral gave 0·2230 $BaSO_4$ = 27·91 per cent. S.; required sulphur, 28·5 per cent.

ORPIMENT (As_2S_3).

Pure material could not be obtained, so that the experiments were made with inferior mineral, and the greatest care was given the oxidation, so that sulphur was not afterwards discovered in the insoluble residue.

0·1150 gram sub. gave	0·2922 gr. $BaSO_4$	= 34·90	per cent.	S.
0·1044 " "	0·2721 "	= 35·79	"	"

The arsenic was also oxidized to arsenic acid. Several tests proved the conversion to be quantitative. Results obtained in this direction will be published later.

JAMESONITE ($Sb_2S_5Pb_2$).

The sulphides of lead and antimony offer no difficulty in the oxidation of their sulphur. This sulpho-salt is decomposed with equal facility. A current of two ampères per minute was employed. The crucible was the anode for ten minutes, and the cathode for an equal period.

(I)	0·1078 gram mineral gave	0·1426 gr. $BaSO_4$	= 18·16	per cent.	S.
(II)	0·1093 " "	0·1447 "	= 18·18	"	"

Required S = 18·30 per cent.

ENARGITE (AsS_4Cu_3).

The oxidation was made in the same manner as in jamesonite:

0·1102 gram mineral gave 0·2449 gr. $BaSO_4$ = 30·52 per cent. S.

A second sample, oxidized with nitric acid, gave 31·00 per cent. S.

STEPHANITE (Ag_5SbS_4).

This mineral was oxidized without difficulty. The conditions under which it was worked were similar to those of the preceding minerals:

(I) 0·1044 gram substance gave 16·69 per cent. S.
(II) 0·1109 " " 16·55 " " Theory req. 16·20 p. c. S.

KOBELLITE ($(Bi\ Sb)_2\ S_5\ Pb_2$).

The sulphur in this mineral was oxidized with ease:

(I) 0·1136 gram sub. gave 0·1562 gr. $BaSO_4$ = 18·38 per cent. S.
(II) 0·1157 " " 0·1594 " = 18·41 " "

The sample here oxidized was of the same material as that analyzed by Dr. Keller (*Proc. Chem. Sec. Franklin Inst.*, **1**, 127). On comparing the mean of his four sulphur determinations with the results obtained by the electrolytic method, it will be seen that the latter does not lack in completeness:

Current Oxidation.	*Nitric Acid Oxidation.*
Sulphur percentage.	18·37, 18·33, 18·46, 18·39
18·38—18·41.	Mean, 18·39 per cent. S.

TETRAHEDRITE ($(Sb,As)_2S_7(Cu_2,Hg_2,Fe,Zn)_4$).

Quite a number of sulphur determinations and complete analyses of tetrahedrite of the above composition were made in this laboratory during the college year just closed. In all of these the chlorine method was employed for decomposition purposes. The percentage of sulphur found was 24·48 per cent. Samples of the same were then exposed to the action of a current of two ampères for twenty minutes, and the sulphuric acid determined in the usual manner with these results:

(I) 0·1073 gr.	mineral	gave	23·81	per cent.	S.
(II) 0·1096	"	"	24·38	"	"
(III) 0.1086	"	"	24·23	"	"
(IV) 0·1095	"	"	24·37	"	"

Tetrahedrite seemed to require the full time (twenty minutes) for oxidation, for in several instances, where the current was interrupted after acting fifteen minutes, the alkaline solution became quite turbid upon acidulation.

STANNITE (SnS_4Cu_2Fe).

The conditions here were the same as those already mentioned for the other sulpho-salts:

(I) 0·1087 gram	mineral	gave	28·61	per cent.	S.
(II) 0·1091	"	"	28·02	"	"

PYRRHOTITE ($Fe_{11}S_{12}$), MARCASITE (FeS_2) AND PYRITE (FeS_2).

The sulphur in the first of these three minerals is very readily changed to sulphuric acid. None of its iron passes into solution, so that the barium sulphate, after ignition, was perfectly white in color. The residue, not soluble in water, showed no unoxidized sulphur:

(I) 0.1087 gram	mineral	gave	0·3049 gr. $BaSO_4$	=	38·51	per cent.	S.
(II) 0·1067	"	"	0·3014 "	=	38·79	"	"

By oxidation with nitric acid the sulphur found was 38·78 per cent. S.

An exceedingly pure specimen of marcasite was exposed to the action of the current. Its sulphur was rapidly and completely oxidized:

0·1043 gram substance gave 0·4056, gr. $BaSO_4$ = 53·40 per cent. S. Required S. = 53·33 per cent.

While these sulphides of iron parted with their sulphur with great ease, pyrite held half of its sulphur content quite tenaciously, notwithstanding it was exposed to the influence of much more powerful currents than the other two minerals.

(I) 0·1667 gram pyrite and 20 grams KOH were exposed for ten minutes to the action of a current giving one ampère per minute. The crucible served as anode for half the time. The sulphur that was oxidized equalled 24·53 per cent.

(II) 0·3080 gram pyrite, 30 grams KOH, and a current as in (I) gave 22 per cent. S.

A number of similar trials gave about the same results. As chalcopyrite was oxidized without difficulty (*Proc. Chem. Sec., Franklin Institute.* **1**, 53), the thought suggested itself that possibly the addition of cupric oxide might prove beneficial. Accordingly, the following experiments were made:

(III) 0·1009 gram pyrite, ·0611 gram CuO, 25 grams KOH, and a current of one and one-half ampères gave 36·39 per cent. S.

(IV) 0·1021 gram pyrite, ·0710 gram CuO, 25 grams KOH, and a current of one and one-half ampères gave 35·02 per cent. S.

(V) 0·1007 gram pyrite, ·0550 gram CuO, 25 grams KOH, and a current of one and one-half ampères gave 30·93 per cent. S.

The time in each trial was twenty minutes. While the addition of the cupric oxide apparently favors the sulphur oxidation, the results are anything but concordant.

(VI) 0·1000 gram pyrite, ·0950 gram CuO, 25 grams KOH, with a current of two ampères, for twenty minutes, gave 51·24 per cent. S.

(VII) 0·1000 gram pyrite, 0·1000 gram CuO, and other particulars the same as in (VI), gave 38·00 per cent. S.

The residues all contained unoxidized sulphur.

(VIII) 0·1045 gram pyrite, ·0523 gram CuO, 25 grams KOH, and a current of two and one-half ampères per minute, gave 46·93 per cent. S.

(IX) 0·1000 gram pyrite, ·0500 gram CuO, otherwise as in (VIII), gave 46·97 per cent. S.

(X) 0·1123 gram pyrite, 0·1400 gram CuO, 25 grams KOH, and a current of two and one-half ampères, gave 41·67 per cent. S.

(XI) 0·1160 gram pyrite, 0·1100 gram CuO, 25 grams KOH, and a current of two and one-half ampères, gave 51·26 per cent. S.

These examples are but a few of the many trials carried out to obtain all the sulphur. The final satisfactory results were obtained in the following manner:

(XII) 0·1060 gram pyrite, an equal quantity of cupric oxide, 28 grams KOH, and a current of four ampères per minute, gave 53·6 per cent. S.

The residue remaining, after treating the fused alkaline mass with water, was dissolved in nitric acid, diluted to 75 cc. with water, and tested with a solution of barium chloride.

No barium sulphate was precipitated on warming the solution, or even after allowing the same to stand for some days.

(XIII) 0·1048 gram pyrite, an equal quantity of cupric oxide, 28 grams KOH, and the current as in the preceding experiment, gave 53·02 per cent. S.

The residue did not contain sulphur. The time given for the oxidation in each of these experiments was twenty minutes, and the current was reversed after it had acted ten minutes.

Several trials were made with the view of ascertaining whether with conditions precisely analogous to those in the last two experiments, the copper oxide omitted, it would be possible to completely oxidize all of the sulphur. They proved failures. A current of five ampères, with cupric oxide absent, was insufficient for the complete conversion of the sulphur into sulphuric acid.

The sulphur of pyrrhotite was readily oxidized. Indeed, this mineral conducted itself very much like the monosulphides, zincblende, galenite, etc. Marcasite, too, offered no difficulty. Since it and pyrite differ only in crystalline form, can it be that the latter property alone is the cause of the greater stability of the pyrite? Will this explain its tenacious hold upon the sulphur? If this be true, why should not this stability extend to the two sulphur atoms? More than forty trials with pyrite show that it is only about half the sulphur which the current changes to sulphuric acid. At least such was the case when cupric oxide was not added. The same current strength that does this amount of oxidation with pyrite will convert *all* the sulphur in marcasite into sulphuric acid.

The writer would here acknowledge his indebtedness to Profs. Koenig and Keller for the mineral material consumed in this investigation, and also to Mr. D. C. Wallace for most valuable assistance in carrying out the oxidations and general analytical work.

UNIVERSITY OF PENNSYLVANIA,
Philadelphia, June 7, 1890.

NOTES AND COMMENTS.

CHEMISTRY.

THE CHEMISTRY OF TANNINS—C. Etti (*Monatsh*, **10**, 647 and 805, through *Journal of Society of Chemical Industry*).—The results of previous investigations have shown that the tannin $C_{17}H_{16}O_9$ obtained from *Quercus robur L*, and that obtained from *Quercus pubercens W*, occur in the oak bark not only in the form of tannic acid, but also as the anhydride; it was also found that the tannic acids, which are almost insoluble in water, do not occur in combination with a sugar, and are not therefore glucosides; their basis is not tannin, but a substance isomeric therewith, namely, a ketone acid (gallylgallic acid) of the constitution—

$$(OH)_3.C_6H_2.CO.C_6H(OH)_3.COOH,$$

formed from two molecules of gallic acid with elimination of one molecule of water.

In this paper the author gives an account of experiments, which show that the tannic acid $C_{16}H_{14}O_9$ is a derivative of the ketone acid referred to above; as this tannic acid closely resembles the acids previously investigated both in physical and chemical properties, it follows that they also are derivatives of the same ketone acid.

The greater part of the sparingly soluble ketone tannic acid occurs in the plant in combination with a metallic base, probably magnesium, and as these salts are very readily soluble in water, they can be easily and completely extracted. After concentrating the aqueous extract and acidifying with hydrochloric acid, the tannic acid is precipitated in an insoluble condition, and can be washed free from hydrochloric acid and then purified by extracting with alcohol or ether. The most suitable source of these acids are the commercial extracts, which are obtained from the bark and wood of various trees and largely used in tanning.

The author has isolated the following tannic acids by the method described above. An acid of the composition $C_{16}H_{14}O_9$ from the extract obtained by the Oak Extract Company in Slavonia, from the wood of the stalk-oak. An acid of the composition $C_{18}H_{18}O_9$ from the oak-bark used in a tannery at Pesth. An acid $C_{20}H_{22}O_9$ obtained from the bark of the copper-beech in the neighborhood of Salzburg. An acid of the composition $C_{22}H_{26}O_9$ from the hop cones obtained from Saaz. All these tannic acids have a different color, varying from brownish-red to bright red; those obtained from the stalk-oak and holm-oak give in dilute alcoholic solution a deep blue, the others, however, a green coloration with ferric chloride. It seems that all the tannic acids obtained from the oak are simply different derivatives of the same ketone tannic acid.

The tannic acid $C_{16}H_{14}O_9$ is a brownish-red amorphous compound; under the microscope it is seen to consist of small spherical nodules, which

are all so much alike that the presence of impurities can be easily detected. It is almost insoluble in water and ether, but readily soluble in alcohol and acetone. Its solution in dilute alcohol has an acid reaction, gives a precipitate with lead acetate and a dark blue coloration with ferric chloride. The formation of the phenylhydrazine-derivative, $C_{22}H_{20}N_2O_8$, and the oxime, $C_{16}H_{15}NO_9$, proves that the acid contains a ketone group.

When the acid is heated with dilute sulphuric acid at 120°–130°, it gives gallic acid (m. p. 238°–240°) and a large quantity of insoluble anhydro-derivatives. It forms a soluble neutral salt and several very sparingly soluble basic salts with magnesium. When heated alone at 130°–135°, or at 100°, with water in sealed tubes, or when boiled with hydrochloric or dilute sulphuric acid, it yields various very stable anhydrides, a property which is especially characteristic of the ketone tannic acids, and serves to distinguish them from tannin. When the acid is boiled with dilute (1–10) sulphuric acid, for example, as long as a red precipitate is produced it is converted into an acid anhydride, $C_{32}H_{24}O_{16}$, according to the equation—

$$2C_{16}H_{14}O_9 - 2H_2O = C_{32}H_{24}O_{16}.$$

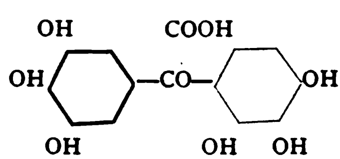
When heated at 120°–130°, under the same conditions, it gives two anhydrides. The one is soluble in ninety-six per cent. alcohol and is formed according to the equation—

$$2C_{16}H_{14}O_9 - 4H_2O = C_{32}H_{24}O_{14}.$$

The other is insoluble in ninety-six per cent. alcohol, and no longer contains a carboxyl group, its formation being expressed thus:

$$2C_{16}H_{14}O_9 - 5H_2O = C_{32}H_{18}O_{13}.$$

These experiments show that the tannic acid contains four hydroxyl groups; its behavior with hydrochloric and with hydriodic acid shows that it contains two methoxy groups. The acid, $C_{16}H_{14}O_9$, is therefore a dimethyl derivative of a ketone acid of the constitution—



but the position of the two methoxy groups has not yet been determined.

H. T.

On a new Reaction of Tannin—Dr. Carl Böttinger (Liebig's *Annalen*. No. 256, p. 341).—When tannin and phenylhydrazin are boiled together in watery solution in the proportion of 2 to 1 or better 1 to 1, or heated to 100° in the proportion of 1 to 2, with exclusion of water, a solution is effected, there occurs an evolution of gas, and a mixture of several bodies is formed. Some of these bodies are soluble in ether and some are not, the latter are not completely soluble in sodium hydrate solution, the ether-alcohol solution of the former is quickly decolorized by zinc dust and hydrochloric acid.

That portion of the above product which is soluble in ether and hot water has the property, when carefully treated with sodium hydrate, of giving a beautiful green-blue solution, the phenylhydrazin separating at the same time. Neither gallic nor pyrogallic acid gives this result.

The peculiar body which causes the above color is prepared by heating the tannin and phenylhydrazin, as above stated, in a water-bath for four hours, the watery solution is separated from the pasty precipitate and the latter dissolved in hot water, treated with hydrochloric acid and allowed to cool. To separate coloring matter, the solution is agitated with ammonia and then set aside for some time when it coheres. The separated solution is extracted with ether, evaporated, the residue heated with alcohol and the solution treated with ether, whereby phenylhydrazin chloride is precipitated and the body remains in solution. From water it crystallizes in colorless rosettes, which on exposure to air become yellow.

It is very soluble in hot water, and when once separated from solution dissolves in cold water with difficulty, it is easily soluble in warm alcohol, but slowly soluble in ether. Acetic acid readily dissolves it. Hot concentrated hydrochloric acid decomposes the pure body but slightly.

It is easily dissolved by warm phenylhydrazin. If this solution is mixed with acetic acid and warmed, there is formed an oily liquid easily soluble in ether, which dissolves in soda solution with a green-blue color.

Extract of sumac yields the same reaction with phenylhydrazin that tannin does, while oak-bark extract does not give it.

The compound obtained from gallic acid and phenylhydrazin is soluble in sodium hydrate solution with a reddish-yellow, orange or golden color.

H. T.

THE OXIDATION OF GALLIC ACID OF TANNIN AND OF THE OAK-TANNINS—Dr. Carl Böttinger (*Liebig's Annalen*, No. 257, p. 248).—The author, some years ago, showed that oak-bark red, as well as oak-bark phlobaphene, is decomposed by dilute nitric acid with considerable evolution of gas and the formation of oxalic acid and several other acids which can be separated from one another in the form of calcium salts. The yield of these acids, however, is small, scarcely amounting to six per cent. of the original material.

The first oxidation was carried out on the precipitate obtained by sulphuric acid on oak-bark extract, but so much calcium sulphate adhered to the salts as to render their purification impossible. It has also been shown that the oxidation products of oak-wood tannin of oak-bark red and of oak-bark phlobaphene are identical.

By the oxidation of gallic acid and tannin with nitric acid; there is formed a solution which, when treated with calcium carbonate, yields beside oxalate, two other calcium salts, one of which is almost insoluble in water, while the other is soluble. Gallic acid yields only a very small quantity of the former, but tannin rather more, which by estimation of its calcium showed it to be trioxyglutarate of calcium, with one molecule of water.

The easily soluble calcium salt was precipitated from its watery solution

by alcohol. The analysis of that from both the gallic acid and the tannin indicate it to be trioxybutyrate of calcium.

The oxidation of acetyl oak-wood tannin and of oak-bark red yielded trioxyglutarate insoluble, and soluble trioxybutyrate of calcium as determined by the analyses of these salts.

By varying the amount of nitric acid, easily soluble salts have been obtained, containing somewhat more calcium. H. T.

BOOK NOTICES.

A Technological Dictionary of Insurance Chemistry. By William A. Harris, F.R.S.S.A., F.S.S., etc.; Phœnix Fire Office. Liverpool: 1890.

This elaborate work of 407 pages, 8vo, by the well-known secretary, surveyor and insurance expert, who has long been connected with the Phœnix Fire Office, England, is well worthy of being a permanent book of reference in the offices of all fire insurance underwriters, their agents and brokers throughout the world, also in the offices of all fire-extinguishing departments and insurance patrols in cities and towns. It is on same plan as Mr. Harris' *Dictionary of Fire Insurance*, which was reviewed some months ago in this journal. The present work, however, has special reference to spontaneous ignition and the chemical causes thereof; also intended to aid in clearing from the records of fires some of the too numerous "unknown" causes.

The principal subjects treated are "Spontaneous Combustion, Oxidation, Chemical Affinity, Fermentation, Friction, Expansion of Gases, Inflammability of Vapors, Dust Explosions, Steam Heating and Drying, Oils, Fibres Coal, Cotton, Mixed Cargoes, etc., with actual cases showing where losses have occurred; also miscellaneous chemical and physical information."

A few illustrations will show more clearly the intention of the work: Naphtha is given about three-quarters of a page. Though the fact is known to specialists, it is not generally known that the electric spark will ignite naphtha vapor, when a glowing coal or lighted cigar will not do so. Naphtha and turpentine burn more fiercely on the moderate application of water; they must be deluged or a wet blanket applied at the earliest moment. Illuminating gas may be fired by red-hot metal, but to ignite hydrogen a flame (though it may be excessively small) is required. In naphtha drying-rooms, where the vapor is present, fires have been occasioned while scraping the floors, by the iron scraper striking a spark on a nail. Had an instrument of phosphor-bronze (whose chief component is copper) been employed, no spark would have resulted from such contact.

Much space is given to the danger from ignition of oiled rags and oiled waste, with some instructive examples of fires caused thereby and by oils, oxidation of oils and oxidation in general. Some of the other subjects liberally treated and exemplified in this technical dictionary are: Coal tar, nitre, quicklime, cotton, cotton cargoes, cotton compressing and bagging,

cotton fires from friction and in various localities (including two pages for the circular issued by the National Board of Marine Underwriters, of New York, respecting cotton cargo fires and means to use when they occur) also modes of ventilating dangerous cargoes, besides jeorpardy arising from sawdust, steam pipes, varnish and various acids in commercial and industrial use.

A great amount of valuable information is given respecting numerous chemicals, and their influence in causing or increasing ignition. The few citations above made will show the practical nature of the subjects treated; and the mode in which they are handled renders them peculiarly available for popular use. N.

METHODS OF REDUCING THE FIRE LOSS. By C. J. H. Woodbury. Boston: Brochure, 33 pp.

This pamphlet publishes a paper read before the American Society of Mechanical Engineers, and contains some excellent suggestions for the correct care of industrial establishments in particular, also much information respecting proper construction of industrial buildings. What is known as the "slow-burning mode of construction" for floors, ceilings, roofs and partitions is strongly advocated, as it well deserves. There are also discussed, automatic dampers for dust flues, spontaneous ignition of bituminous coal, fire apparatus in general and sprinklers in particular. The author favors one-story factories, especially for cotton and woollen mills, and gives some illustrations thereof. This brochure will be of advantage to any owner or manager of an industrial establishment. N.

SLIDE-VALVE GEARS.—By Frederic A. Halsey. Analysis by the Bilgram Diagram. New York: D. Van Nostrand Company, 1890, pp. viii, 135.

As usual, this work has been prepared to meet a real want, and the author considers a mathematical treatment an uncalled-for use of heavy artillery. He finds it necessary to use, however, about the same amount of mathematics any one else requires to cover the same ground, as on p. 28, he says that the demonstration of the Bilgram diagram depends upon a theorem of geometry which he loosely states.

In the preface, the comparison made between the Zeuner and the Bilgram diagram is simply an evidence of the fact that the author does not know what he is talking about. He says: "Valve diagrams are used * * * to analyze existing valve motions and to design new ones. The Zeuner diagram fulfils the first purpose perfectly, but is unsatisfactory when applied to the second." The author evidently means unsatisfactory to him, as from the context it is evident that his knowledge of the Zeuner diagram is limited. "The leading data that are given in designing a valve motion are the point of cut-off, the port opening, and the lead of the valve (not the lead angle of the crank, as is often conveniently assumed). It is the radical defect of the Zeuner diagram that none of these dimensions can be laid off from known points * * * the result sought is only found through blind trial. With Mr. Bilgram's method all this is changed. The lead is laid off from a fixed

line, the port opening from a fixed point and the cut-off position of the crank is located. The lap circle is then drawn tangent to these lines, and the problem is solved." The author does not here state, as on p. 36, that the radius and centre of this circle must be found by trial. The fact is when one knows how to use the Zeuner diagram, this problem is solvable without any blind trial, and this particular objection to the Zeuner diagram falls. The only other objection is what the author calls the awkward conception of the backward rotation of the crank. The same objection could be urged against the Bilgram diagram by one little acquainted with it, and with the same amount of justice. It seems, therefore, that as *the* objection to the use of the Zeuner diagram does not hold, as it is in every way simpler when once understood, as it can be easily applied to link motions and radial gears as well as plain slides, it is preferable to master the Zeuner diagram rather than the Bilgram, if one has not the inclination to study both.

The Bilgram diagram is well handled in Mr. Halsey's book, the descriptions are clear and to the point, and the book is well worth reading.

But the part referring to the use of the diagram is not the most valuable part of it. The author's treatment of the primitive engine is very good. The principal value of the work is, however, to be found in the articles on equalizing the lead, the exhaust, and the cut-off. Considerable of this matter has appeared in the *American Machinist*, but it occupies its proper place in the work, and is in every way excellent. Rules are given for determining the size of the steam and exhaust pipes and area of the ports and the method of determining all the dimensions of the plain slide is clearly shown. In addition to the part treating of slide valves with fixed eccentric, one part treats of the plain slide with shifting and swinging eccentric; and a third of independent cut-off valves.

The book is well illustrated, has an admirable index, and is well worth having.

H. W. S.

PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR JUNE, 1890.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, June 30, 1890.

TEMPERATURE.

The mean temperature of 58 stations for June, 1890, was 70°·3, which is about 2° above the normal, and 3°·8 above the corresponding month of 1889.

The mean of the daily maximum and minimum temperatures 81°·8 and 58°·4 give an average daily range of 23°·4, and a monthly mean of 70°·1.

Highest monthly mean, 73°·7 at Uniontown and Huntingdon.

Lowest monthly mean, 64°·2 at Dyberry.

Highest temperature recorded during the month, 97° on the 5th, at Carlisle, and 30th, at Lynnport.

Lowest temperature, 33° on the 14th at Charlesville.

Greatest local monthly range, 31°·3 at Wilkes-Barre.

Least local monthly range, 14°·0 at Erie.

Greatest daily range, 47° at Lock Haven on 25th.

Least daily range, 2° at Wellsboro on 21st.

From January 1, 1890 to June 30, 1890, the excess in temperature at Philadelphia was 71°4, at Erie 42°·1 and at Pittsburgh 68°·5.

BAROMETER.

The mean pressure for the month, 30·00, is about ·03 above the normal. At the U. S. Signal Service Stations, the highest observed was 30·38 at Pittsburgh on the 9th, and the lowest 29·71 at Erie on the 12th.

PRECIPITATION.

The average rainfall 3·42 inches is a deficiency of nearly a half inch. Owing to local thunder-storms the fall was somewhat unevenly distributed, but the difference was not great when compared in large areas.

The largest totals reported in inches were Forks of Neshaminy 5·74, Columbus 5·66, Mauch Chunk 5·25 and Wilkes-Barre 5·07.

The smallest were Philadelphia 1·30 and Selins Grove 1·36.

The heaviest general rains occurred on the 6th, 11th, 12th, 13th, 21st, 22d and 23d.

NOTE.—*This number of the Monthly Weather Review completes the serial maps of "Isothermal Lines Showing the Normal Temperature of Pennsylvania" for each month of the year. They will not be reproduced in future numbers. The "Mean Temperature and Rainfall" maps, however, will be continued as heretofore.*

WIND AND WEATHER.

The prevailing direction of wind was from the west. Thunder-storms were frequent and caused numerous losses to life and property. The weather was seasonable for growth, although the month was characterized by cool nights. A few light frosts occurred in the northern counties.

Average number: Rainy days, 9; clear days, 12; fair days, 11; cloudy days, 7.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Gettysburg, 6th, 11th, 13th; Charlesville, 4th, 5th, 18th, 22d; Hollidaysburg, 3d, 5th, 6th, 10th, 12th, 22d, 28th, 29th; Tipton, 3d, 5th, 11th; Wysox, 4th, 5th, 6th, 11th; Le Roy, 4th, 6th, 11th, 12th, 13th, 24th; Forks of Neshaminy, 4th, 6th, 11th, 12th; Quakertown, 6th, 11th, 12th, 13th; Johnstown, 6th, 11th, 12th, 13th, 17th, 22d, 23d; Emporium, 3d, 5th, 6th, 11th, 12th, 22d, 28th; Mauch Chunk, 5th, 6th, 11th, 23d; State College, 3d, 11th, 12th, 13th, 22d, 28th; Phillipsburg, 5th; West Chester, 6th, 11th, 12th, 24th; Coatesville, 6th, 11th, 12th; Kennett Square, 6th, 11th, 22d, 23d; Westtown, 4th, 11th, 12th, 13th, 23d; Lock Haven, 3d, 6th, 11th, 12th, 22d, 23d, 28th, 29th; Catawissa, 5th, 6th, 11th, 12th; Meadville, 4th, 5th, 6th, 11th, 17th, 22d; Carlisle, 6th, 11th, 12th, 13th, 21st, 24th; Harrisburg, 4th, 6th, 11th, 12th, 22d, 23d, 24th; Uniontown, 5th, 6th, 11th, 13th, 15th, 17th, 29th; Huntingdon, 3d, 5th, 10th, 11th, 12th, 13th, 22d, 23d; Petersburg, 11th, 22d; Lancaster, 6th, 11th, 12th; Myerstown, 6th, 11th, 12th, 21st; Annville, 5th, 6th, 11th, 12th, 13th, 22d, 24th; Coopersburg, 6th, 11th, 12th; Lynnport, 6th, 12th; Wilkes-Barre, 6th, 11th, 12th; Nisbet, 6th, 11th, 13th, 23d; Greenville, 5th, 11th; Lewistown, 3d, 11th, 12th, 16th, 22d, 23d, 28th; Bethlehem, 4th, 5th, 6th, 11th, 12th, 13th, 23d; Philadelphia, 4th, 6th, 12th, 24th; Girardville, 5th, 6th, 12th, 13th, 14th, 23d, 24th; Selins Grove, 4th, 5th, 6th, 10th, 11th, 12th, 22d, 23d, 24th; Somerset, 6th, 12th, 14th, 15th, 21st; Eagles Mere, 4th, 6th, 11th, 12th, 24th; Wellsboro, 3d, 5th, 6th, 11th, 12th, 13th, 17th, 22d; Lewisburg, 11th, 12th, 13th; Columbus, 4th, 5th, 6th, 11th, 17th, 22d; Canonsburg, 12th; Dyberry, 4th, 5th, 6th, 11th, 12th, 13th, 24th; Ligonier, 22d; South Eaton, 4th, 5th, 6th, 11th, 12th, 13th, 24th; York, 6th, 11th, 12th, 13th, 22d, 23d, 24th.

Hail.—Gettysburg, 11th; Meadville, 11th; Lock Haven, 11th; Huntingdon, 22d; Lancaster, 11th; Greenville, 5th, 11th; Girardville, 12th; Somerset, 3d; Eagles Mere, 4th; Wellsboro, 17th; York, 11th.

Frost.—Grampian Hills, 8th; Meadville, 8th; Somerset, 8th; Wellsboro, 1st, 2d, 8th, 9th.

Sleet.—Phillipsburg, 5th.

Aurora.—Quakertown, 8th, 19th.

Coronæ.—Greenville, 26th, 27th, 28th; Lewistown, 27th, 28th, 29th; Somerset, 22d; Eagles Mere, 26th, 30th; Dyberry, 2d, 23d, 27th.

Solar Halos.—Le Roy, 8th, 9th, 20th, 23d; Meadville, 10th, 16th; Dyberry, 2d, 18th.

Service for June, 1890.

County.	Precipitation. Number of Days Rainfall.	Number of Days. Clear.	Fair.	Cloudy.	Wind. Prevailing Direction. 7 A. M.	2 P. M.	9 P. M.	Observers.
Adams,[1]	10	14	8	8	S	S	S	Prof. E. S. Breidenbaugh.
Allegheny	13	6	20	4	SW	SW	SW	Oscar D. Stewart, Sgt. Sig. Corps.
Bedford,	6	4	18	8	W	NW	SW	Miss E. A. G. Apple.
Berks,[1]	...	...	...	...	...	...	...	C. M. Dechant, C.E.
Blair,[1]	13	...	...	...	...	...	...	Dr. Charles B. Dudley.
Blair,	11	13	10	7	NW	NW	NW	A. H. Boyle.
Blair,	...	12	9	9	W	W	W	Prof. J. A. Stewart.
Blair,	9	...	...	...	W	W	W	Miss Cora J. Wilson.
Bradford,	11	6	10	14	SE	SE	SE	Charles Beecher.
Bradford,	11	6	14	10	SW	SW	SW	Geo. W. T. Warburton.
Bucks,	8	15	6	9	W	W	W	J. C. Hilsman.
Bucks,	6	11	10	9	NW	SW	SE	J. L. Heacock.
Bucks,	...	...	...	...	...	...	...	Lewis P. Townsend.
Cambria,[1]	12	5	18	7	SE	SE	SE	E. C. Lorentz.
Cameron,	10	10	12	5	W	W	W	T. B. Lloyd.
Carbon,[1]	9	14	11	5	NW	NW	NW	John J. Boyd.
Centre,	11	7	15	8	W	W	W	Prof. Wm. Frear.
Centre,	...	4	13	7	SW	SW	SW	Geo. H. Dunkle.
Chester,	9	20	5	5	NW	NW	SE	Jesse C. Green, D.D.S.
Chester,	5	17	6	7	W	S	S	W. T. Gordon.
Chester,[1]	9	12	12	6	N	...	S	Benj. P. Kirk.
Chester,	7	15	8	7	W	W	W	Prof. Wm. F. Wickersham.
Clarion,	...	...	...	...	...	...	...	Rev. W. W. Deatrick, A.M.
Clarion,	...	...	...	...	...	...	...	C. M. Thomas, B.S.
Clearfield	10	11	10	9	SW	SW	SW	Nathan Moore.
Clinton,	12	14	12	4	W	W	W	Prof. John A. Robb.
Columbia	10	...	...	...	...	...	...	Robert M. Graham.
Crawford,	6	12	16	2	SE	S	S	J. & B. H. Metcalf.
Cumberl	8	7	15	8	W	S	S	J. E. Pague.
Dauphin,	10	10	11	9	W	W	W	Frank Ridgway, Sgt. Sig. Corps.
Delaware	...	...	...	...	...	...	...	Prof. Susan J. Cunningham.
Erie,[1]	9	8	8	14	S	W	S	Peter Wood, Sgt. Sig. Corps.
Fayette,	10	15	12	3	SW	SW	SW	Wm. Hunt.
Forrest,	...	...	...	...	...	...	...	R. L. Haslet.
Franklin,	...	...	...	...	...	...	...	Miss Mary A. Ricker.
Fulton,	7	15	11	4	...	...	...	Thomas F. Sloan.
Greene,	11	15	9	6	...	...	...	Capt. W. C. Kimber.
Hunting	8	13	3	14	W	W	W	Prof. W. J. Swigart.
Hunting	11	16	10	4	W	W	W	J. E. Rooney.
Indiana,	...	...	...	...	...	...	...	Prof. S C. Schmucker.
Lackaw	...	...	...	...	...	...	...	C. A. Hinsdell.
Lancast	...	8	6	3	SE	W	W	C. N. Heller.
Lawrence	7	13	15	2	S	S	S	Wm. T. Butz.
Lebanon,	6	...	...	...	W	W	W	Wm. H. Kline.
Lebanon,	...	8	19	3	W	W	W	Geo. W. Bowman, A.M., Ph.D.
Lehigh,	7	11	11	8	E	SE	E	M. H. Boye.
Lehigh,[1]	3	15	11	4	...	...	...	John C. Wuchter.
Luzerne,	7	...	...	...	...	...	...	H. D. Miller, M.D.
Luzerne,	9	18	1	11	NE	NE	NE	A. W Betterly.
Lycomi	7	16	7	7	W	W	W	John S. Gibson, P. M.
Mercer,	7	10	10	10	N	N	N	Prof S. H. Miller.
Mifflin,	12	12	13	5	NW	NW	NW	Culbertson & Lantz.
Montgo	4	21	6	3	W	W	W	Charles Moore, D.D.S.
Northa	7	20	3	7	NW	S	W	Lerch & Rice.
Perry,	...	...	...	...	...	...	...	Frank Mortimer.
Philade	6	9	10	11	NW	NW	NW	Luther M. Dey, Sgt. Sig. Corps.
Potter,	...	...	...	...	...	...	...	C. L. Peck.
Schuyl	8	19	10	1	W	W	NW	E. C Wagner.
Snyder,	4	19	6	5	SW	SW	SW	J. M. Boyer.
Somers	9	8	13	9	SW	SW	SW	W. M. Schrock.
Sulliva	7	9	10	11	SW	SW	SW	E. S. Chase.
Tioga,	12	7	11	12	N	N	S	H. D. Deming.
Union,[1]	6	8	17	5	SW	SW	SW	F. O. Whitman.
Warren	13	9	13	8	SW	SW	SW	Wm. Loveland.
Washi	9	17	10	2	SW	SE	W	A L. Runion, M.D.
Wayne,	10	8	13	9	NW	NW	NW	Theodore Day.
Wayne,	10	...	...	...	...	...	...	John Torrey.
West	...	...	...	...	...	...	...	Hilary S. Brunot.
West	6	17	12	1	...	...	...	J. T. Ambrose.
Wyo	10	12	13	5	S	S	S	Benj. M. Hall.
York,	10	18	10	2	NW	NW	NW	Mrs. L. H. Grenewald.

T. F. Townsend, *Sergeant Signal Corps, Assistant.*

Lansdale.	Forks of Nesham'y.	Germantown.	Point Pleasant.	Bethlehem.	Canonsburg.	Carlisle.	McConnellsburg.	Waynesburg.	Lewisburg.	Mauch Chunk.	Nisbet.	Charlesville.	Lynnport.	Tionesta.	Gettysburg.	Lewistown.	Greensburg.	Tipton.	Coudersport.	Coopersburg.	Hulmeville.	Westtown.	Meadville.	Ligonier.	Scranton.
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. .	·94	1·00	·50	·58	·08	·10	·55	. .	·35	·25	·70	·49	1·00	. .	1·05	·37	. .	·03	. .	·47	. .	·11	·49	·56	. .
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1·57	3·99	·60	·08	·86	·46	·99	·70	. .	1·42	2·71	·10	·55	2·40	. .	·44	·85	. .	·25	. .	1·35	. .	·52	·34	·30	. .
·05	·03	. .	. .	·21	·09	·21	·78	. .	·29	·16	·30	. .	. .	. .	. .	. .	. .	·20	. .	. .	. .	. .	. .	. .	. .
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·56	·64	·50	·71	·80	·60	·22	. .	. .	. .	1·10	·50	. .	1.00	. .	·03	·35	. .	·25	. .	·71	. .	. .	·58	·17	. .
. .	. .	·07	·01	. .	·52	. .	·70	. .	. .	. .	. .	·36	. .	. .	. .	·80	. .	·24	. .	·02	. .	. .	·03	·69	. .
. .	. .	. .	. .	·05	. .	·50	1·18	. .	. .	·87	1 00	. .	. .	. .	·73	·13	. .	·60	. .	. .	. .	·45	. .	. .	. .
·01	. .	. .	. .	. .	. .	. .	. .	. .	. .	·05	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
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2·19	5·74	2·27	3·58	3·10	1·82	2·97	4·87	. .	2·80	5·25	3·50	1·87	4·40	. .	3·91	3·76	. .	1·86	. .	3·14	. .	2·83	1·92	1·94	. .

T. F. T.

Lunar Halos.—State College, 26th; Meadville, 29th; Lock Haven, 27th, 30th; Greenville, 29th; Girardville, 29th; Somerset, 21st.

Meteors.—Lewistown, 24th.

Zodiacal Lights.—Charlesville, 13th, 14th.

WEATHER FORECASTS.

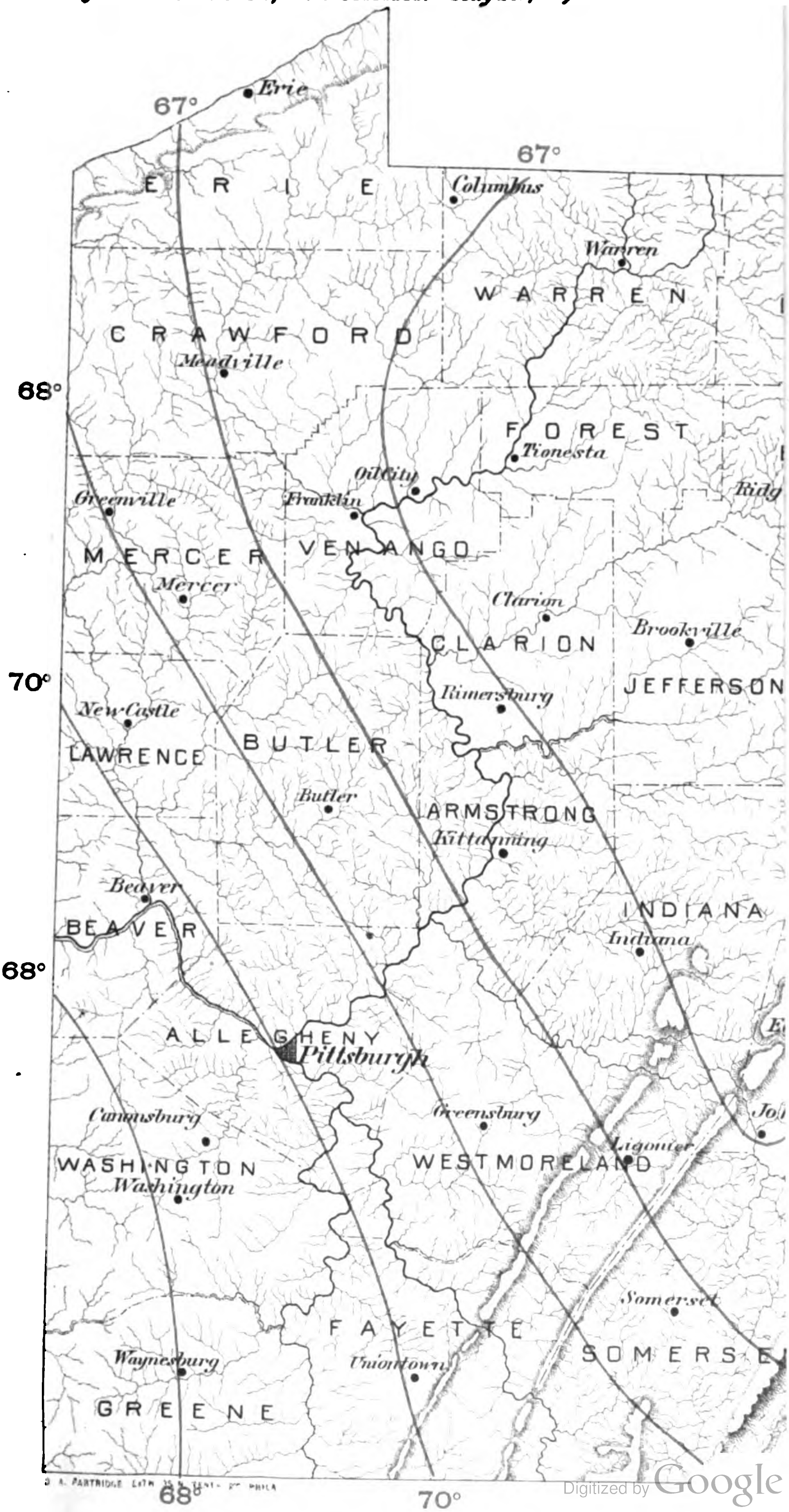
Percentage of local verifications of weather and temperature signals as reported by displaymen for June, 1890:

Weather, 86 per cent.
Temperature, 92 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
C. W. Burkhart,	Shoemakersville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
Capt. A. Goldsmith,	Quakertown.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
New Era,	Lancaster.
State Normal School,	Clarion.
Clarion Collegiate Institute,	Rimersburg.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
J. E. Forsythe,	Butler.
James H. Fones,	Tionesta.
Steward M. Dreher,	Stroudsburg.

Displayman.	*Station.*
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
Hartford P. Brown,	Rochester.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. M. Wildman,	Langhorne.
G. W. Klee,	Chambersburg.
A. Simon's Sons,	Lock Haven.
Raftsman's Journal,	Clearfield.
W. S. Ravenscroft,	Hyndman.
R. C. Schmidt & Co.,	Belle Vernon.
Chas. B. Lutz,	Bloomsburg.
E. C. Lorentz,	Johnstown.
W. M. James,	Ashland.
Miller & Allison,	Punxsutawney.
Dr. A. L. Runion,	Canonsburg.
E. J. Sellers,	Kutztown.
C. A. Hinsdell,	Scranton.
H. J. Fosnot,	Lewistown.
H. M. Kaisinger,	Hartsville.
E. Jennet,	Franklin.
Milton C. Cooper,	Ashbourne.
Geo. W. Bowman,	Annville.
P. S. Weber,	DuBois.
Foulk & Co.,	Milford.
William Lawton,	Wilmington, Del.
Wister Heberton & Co.,	Germantown.
Charles M. Mullen,	Bedford.
E. W. Merrill,	North East.
A. Simon's Sons,	Lock Haven.
Frank Ridgway,	Harrisburg.
G. W. Yost,	Collegeville.
A. C. Tryon,	Spartansburg.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Mercer
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Brookville
CLARION
JEFFERSON
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Rimersburg
New Castle
LAWRENCE
BUTLER
Butler
ARMSTRONG
Kittanning
Beaver
BEAVER
INDIANA
Indiana
68°
ALLEGHENY
Pittsburgh
Greensburg
Canonsburg
Ligonier
WASHINGTON
WESTMORELAND
Washington
Somerset
FAYETTE
SOMERSET
Waynesburg
Uniontown
GREENE
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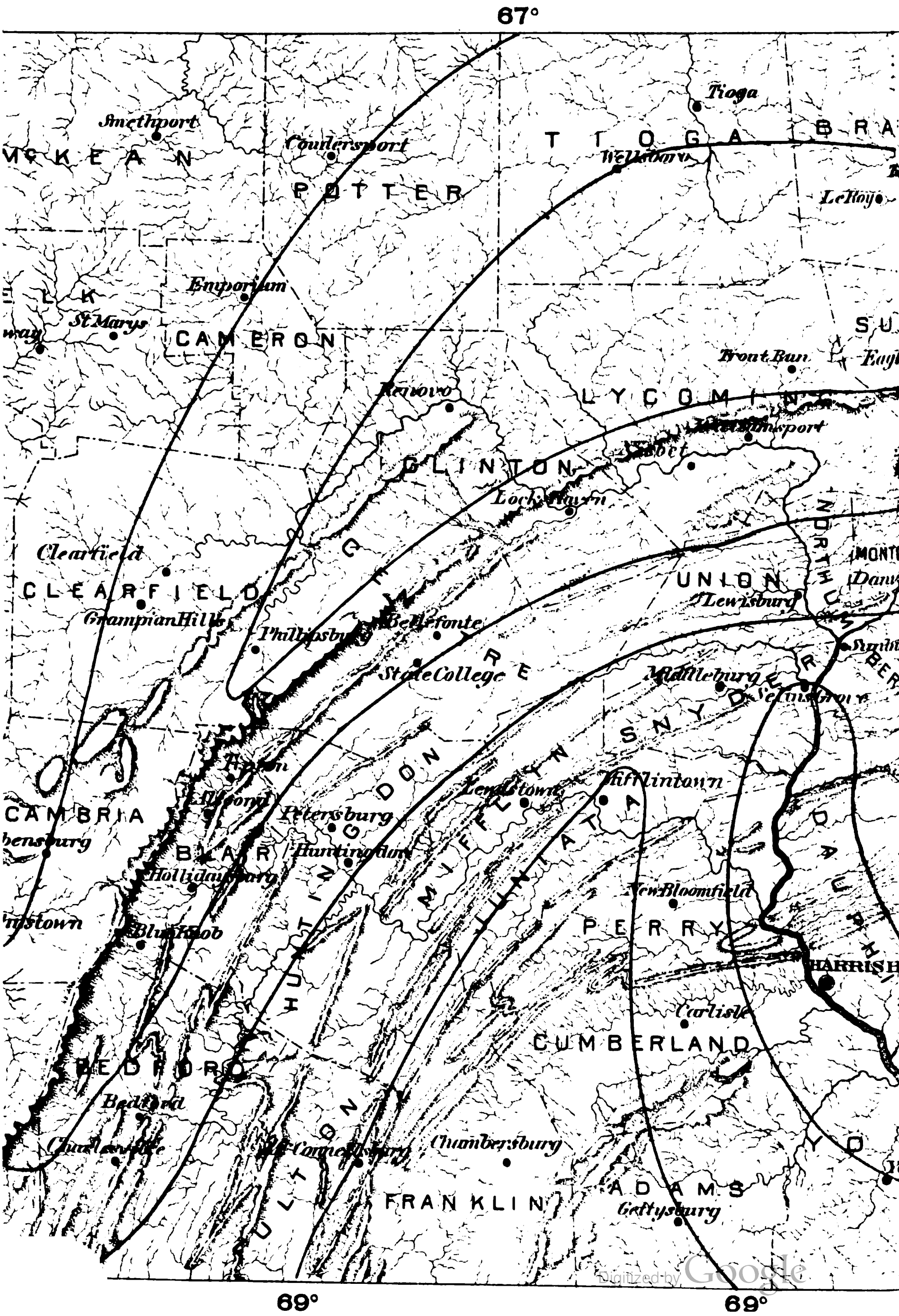
70°

ISOTHERMAL LINES,

SHOWING THE

NORMAL TEMPERATURE OF PENNSYLVANIA FOR



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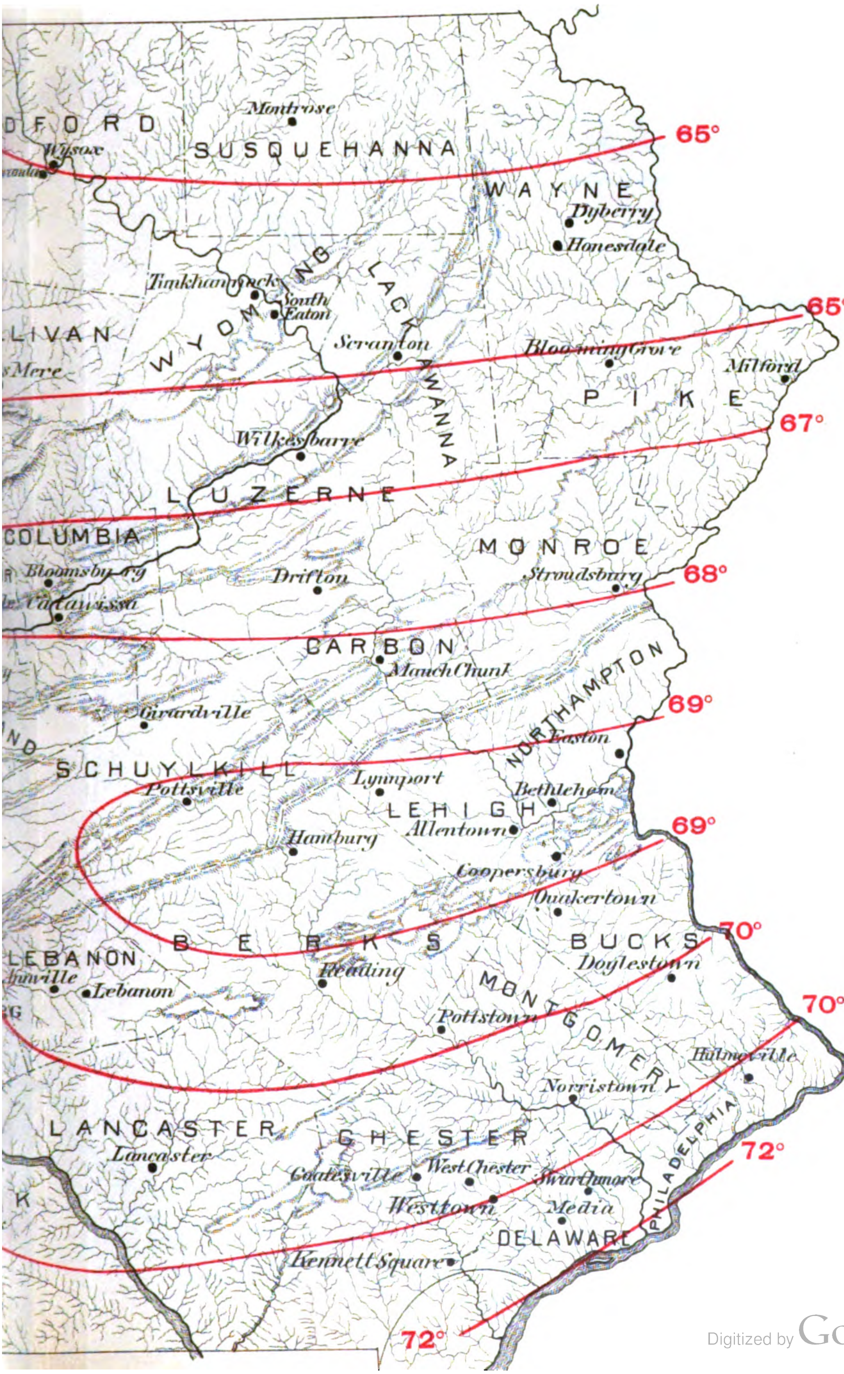

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LUZERNE
COLUMBIA
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Stroudsburg
CARBON
Mauch Chunk
NORTHAMPTON
Easton
Girardville
SCHUYLKILL
Pottsville
Lynnport
LEHIGH
Bethlehem
Allentown
Hamburg
Coopersburg
Quakertown
BERKS
BUCKS
Doylestown
LEBANON
Lebanon
Reading
MONTGOMERY
Pottstown
Hulmeville
Norristown
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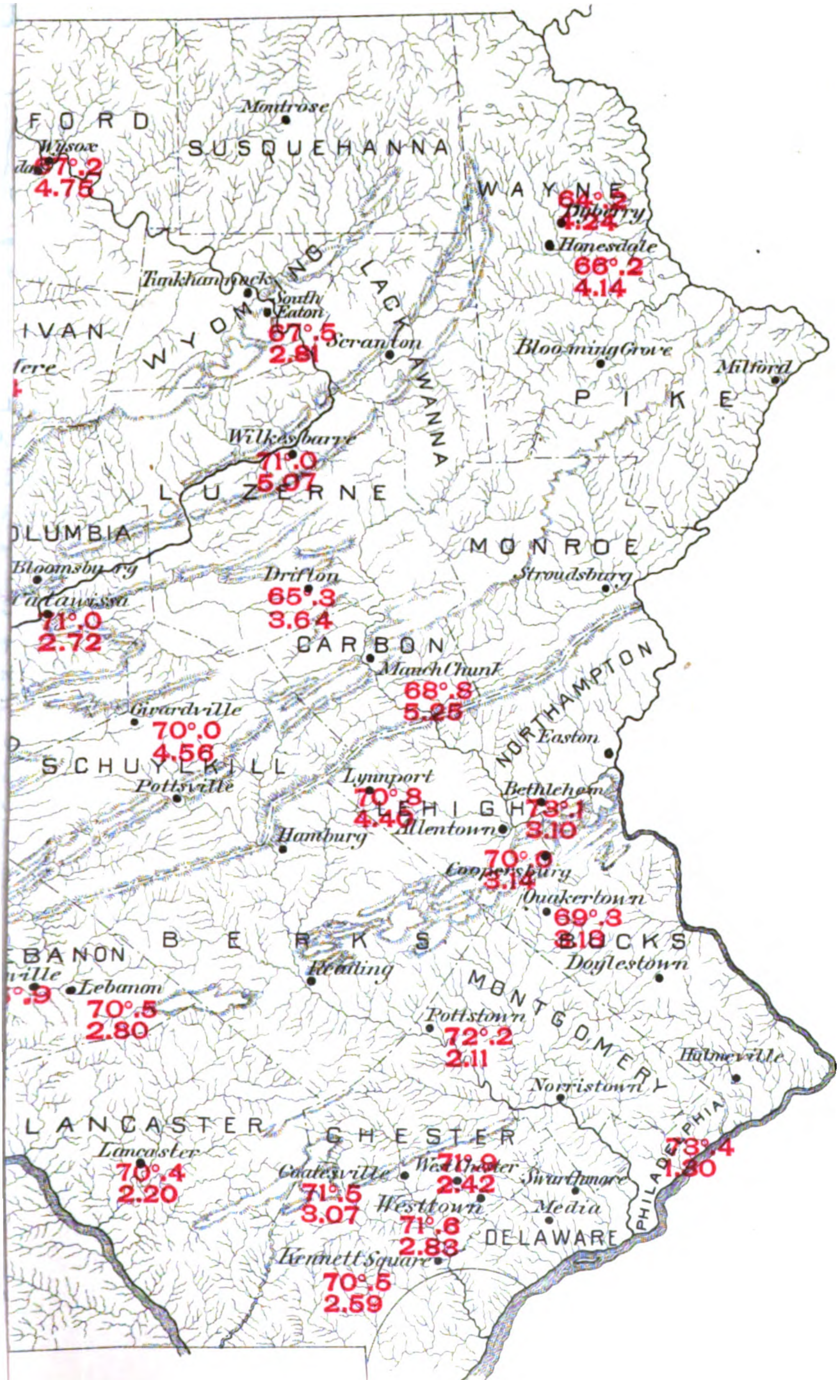
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Honesdale
66°.2
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Tunkhannock
South Eaton
67°.5
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Milford
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Allentown
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Coopersburg
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West Chester
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Swarthmore
Westtown
71°.6
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Media
DELAWARE
Kennett Square
70°.5
2.59

Hall of the Institute.

JULY, 1890.

Notice is hereby given that the Committee on Science and the Arts of the FRANKLIN INSTITUTE has recommended the award of

The Elliott Cresson Medal

TO

STOCKTON BATES, EDWIN F. SHAW AND
GEO. M. VON CULIN,

for their Improvements in

"SUPPORTS FOR SPINNING SPINDLES."

Any objection to the above recommendation should be communicated within three months of the date of this notice to the Secretary of the FRANKLIN INSTITUTE, Philadelphia.

WILLIAM H. WAHL, Secretary.

Coll Ay

Entered at the Post Office at Philadelphia in accordance with Section 199 of the Postal Laws and Regulations.

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CONTENTS.

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OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXX. SEPTEMBER, 1890. NO. 3

PRECIOUS STONES.

BY GEORGE F. KUNZ.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *February 17, 1890.*]

The Lecturer was introduced by Prof. PERSIFOR FRAZER, of the INSTITUTE, and spoke as follows:

MEMBERS OF THE INSTITUTE, AND LADIES AND GENTLEMEN:

The lecture this evening, aside from some general descriptions, will consist of a synopsis of some recent information on the subject of gems, precious and ornamental stones—in other words, the more important discoveries that have been made and the changes that have taken place during the past ten years; together with a few notes on the precious stones exhibited at the Paris Exposition.

What is a precious stone? The answer to this ques tion is not easy; for the value of a particular kind of stone is often due in great measure to the caprice of fashion

or to some adventitious circumstance of time or place; and some stones that are to-day of small value have, during certain periods in the past, almost displaced the diamond or the ruby in public estimation. Beauty of color, hardness and rarity are the essential qualities which entitle a mineral to be called precious. Strictly speaking, the only precious stones are the diamond, ruby, sapphire and emerald, though the term is often extended to the opal, notwithstanding its lack of hardness, and to the pearl, which is not a mineral, but strictly an animal product.

Popularly, a gem is a precious or semi-precious stone, when cut or polished for ornamental purposes. Mineralogically, the term designates a class or family of minerals hard enough to scratch quartz, without metallic lustre, but generally brilliant and beautiful, and includes the semi-precious or fancy stones (called pierres de fantasie by the French), such as the chrysoberyl, alexandrite, tourmaline, spinel, topaz, garnet and amethyst. Archæologically, the term is restricted to engraved stones, such as intaglios and cameos. The term jewel is applied to a gem only after it has been mounted.

The epithet phenomenal is used in regard to stones which exhibit an unusual or singular play of color, such as opal, moonstone, sunstone and Labrador spar; or which change their color by artificial light, like alexandrite; or show a line or band or bands of light, as the line in the cat's-eye and the star in the sapphire and ruby asteria.

Before mineralogy became the exact science that it is to-day, and even at the present time, precious stones were determined only by the eye; hence, in ancient times, they were confused with one another, as unfortunately they are sometimes in the present age; so that the ruby, spinel, garnet and rubellite were all probably known as carbuncle, and the yellow sapphire, yellow topaz, yellow quartz, yellow zircon and yellow tourmaline were all known as topaz.

At present, however, the eye, which is not always accurate, is not alone depended on. Specific gravity and certain other methods are now employed in the exact determinations of precious stones. First, by specific gravity occa-

sionally by means of solutions (such as Sonstadt's or Thoulet's solution, the double iodide of potassium and mercury) which can be made to vary from over three times the weight of water to the specific gravity of the gem lowest in the scale; again, by the aid of the scale of hardness, the diamond being ten, sapphire nine, topaz eight, quartz seven, feldspar six, apatite five, flüorite four, and calcite three. Among optical means, we find the dichroscope of great assistance, as many gems possess dichroitic properties, showing two images of each object viewed, and these differ in color in the various gems; by the use of the spectroscope we find that the ruby gives a bright red band, the garnet a large series of absorption bands, etc. By means of the polariscope, the crystalline system to which the precious stone belongs can be readily determined. By passing a cut stone of yellow or white quartz through the fingers and a yellow topaz of the identical shade of the quartz, we find that the topaz is slippery, while the quartz offers considerable resistance. Certain gems are electrical, notably so, amber, tourmaline and topaz, the latter retaining this property for some time after heating.

The diamond crystallizes in the isometric system, and is usually found as an octahedron or as some modification of that form. It is ten in the scale of hardness, and is the hardest of all known substances. Its composition is pure carbon. It has a greater refractive and dispersive power on light than any other gem, and is the only one that is combustible. Its specific gravity is about 3·525. In color, its range is extensive, it having been found in almost every color of the spectrum, though more commonly white, yellow, brown; rarely rose-red, red, blue, and green.

An impression seems to prevail that a diamond will not break if struck with a hammer on an anvil, and more than one fine stone has been shattered in attempted tests, thus proving the fallacy of the assertion. While the diamond is very hard, it is also very brittle, and can be easily broken; and although every substance, from the hardness of feldspar up, including a cleavage or cut diamond, will scratch

glass, nothing but the natural edge of a diamond crystal will cut it. If a stone will scratch corundum, and is not scratched by a diamond, it is safe to assume that it is a diamond. It is well to make the trial on a smooth or polished surface, otherwise the scratch will not be perceptible.

The author of the *Arabian Nights* undoubtedly thought he was imagining the wildest and most improbable things when he wrote of Sinbad the Sailor's obtaining his treasures in the Valley of Diamonds; yet the African mines have paled this profusion of wealth into utter insignificance. A glimpse of these new Valleys of Diamonds may prove interesting. Before the opening of the South African mines, the primitive method of washing diamonds was carried on by thousands of slaves, who, like those who built the pyramids under the lash of the Pharaohs, simply obeyed a master who mercilessly goaded them on, whip in hand. This method is, to-day, replaced by the most ingenious and powerful machinery, which, eyeless though it be, allows fewer diamonds to escape than would the keenest and most disciplined army of washers.

At the Kimberley Diamond Mines, in South Africa, wonderful progress has been made in the last decade. About 1877, the work of consolidation of the different companies began. Originally, the mines were worked as 3,238 separate claims, each thirty-one feet square, separated by a seven-and-a-half-foot roadway.

A mine in the early days was a bewildering sight. Miles of wire cables were stretched across it in all directions, and to these were attached the buckets for carrying the earth, reef, or wall-rock of the mines, or, at times, water, and all running from individual claims. Some of these latter were almost level with the surface, while others next to them might be cut down 200 feet, and others only 100 feet, yet all were worked independently. At the sides were endless belts, with pockets for carrying the earth. The result of this independent system of working was that rock was dropped so recklessly that, it is said, the vicinity of the claims was as dangerous as a battle-field. The loss of life was great, not from this source only, but also from the fall-

ing of immense masses of reef, loosened by the blasting, which several times buried a score of men at once. But improved methods were gradually introduced. Steam railroads were run down into the mine, and parts of it were levelled. Millions of tons of reef required moving, and millions of gallons of water required to be pumped to the surface; the only way to do it was to assess every company in the mine proportionally. Many mistakes were made at first, if mistakes they can be called, when the problems offered for solution were entirely new and untried. The yellow or surface soil which overlaid the blue stuff pulverized so readily that it could be taken to the washing machine directly, but as the claims were sunk down in the blue earth, the rock grew harder, and dynamite became necessary. Immense quantities of it are now used for blasting. On January 10, 1884, through carelessness, thirty tons of dynamite and ten tons of blasting-powder and gelatine, in all worth $80,000, exploded with terrific effect; the smoke column was 1,000 feet high, and visible at the River Diggings, thirty-five miles distant.

After the earth "blue," as the diamond rock is called, is raised, it is put on the sorting ground, where it is partly disintegrated by water and the action of the atmosphere. It is then broken by hand and taken to the "compound" or diamond sorting machine, a large machine into which the rock is thrown from the sorting and breaking floors. It is here broken into still smaller fragments and then passed down into large vats, containing immense centrifugal wheels, on which, as they rapidly revolve, the rock is finely divided. The lighter materials, such as altered olivine, quartz, mica and mud are then floated out, while the diamonds, garnets (some of which are exceedingly rich in color and of large size, are sold under the name of cape rubies,) and other heavy minerals are concentrated together in the lowest part of the "compound." So carefully is the rock and earth washed that all the diamonds down to the size of a pinhead are saved.

Since great depths have been reached, and even before, the recent consolidation became an absolute necessity to work the mines.

A prize of £5,000, offered for the best tunnel or shaft system for use at the Kimberley Mines, was awarded to the Jones system, which is sunk on the coffer-dam principle. At present there are many shafts and inclined planes in the Kimberley Mine alone, all sunk at some point in the reef outside of the mine. From 11,000,000 to 13,000,000 gallons of water were annually hoisted from the Kimberley Mines, at a cost of sixpence per load of 100 gallons.

Five years ago, in addition to many miles of aërial tramways, there were over 170 miles of tramway around the four Kimberley Mines; while 2,500 horses, mules, and oxen, and 350 steam-engines, shafts, etc., representing 4,000 horse-power, were employed in the work. One million pounds sterling were annually expended for labor, and over £1,000,000 for fuel and other supplies. The gross capital of the companies was then nearly £10,000,000. Over 10,000 natives, each receiving £1 a week, and 1,200 European overseers, at an average wage of £5, were employed.

The supposition so long talked of, that a unification would ultimately be accomplished, and the diamond mines consolidated into one gigantic trust for the regulation of prices and production has been realized, the DeBeer's Mine Company having absorbed so many companies during 1888 and the early part of 1889, that they control the output of mines which yield twenty-nine-thirtieths of all the diamonds in the world. As a result, they have limited the production. The cost of mining having become necessarily higher, as it was carried to greater depths and larger dividends were required to pay the interest on the stock of the DeBeer's Mining Company, which now amounted to between £18,000,000 and £20,000,000; cut diamonds have therefore advanced twenty-five per cent. in value during the last nine months of 1889, and the price is not likely to recede. The advance of twenty-five per cent. on the cut stones is equal to nearly seventy-five per cent. on the rough material. One effect of the increased price of rough stones and the limitation of the output, has been that some thousands of diamond cutters have been thrown out of employment at Antwerp and Amsterdam.

On the other hand, one benefit of the consolidation has been the introduction of what is known as the compound system, by which the "boys," as the miners are called, are housed and fed under contract for a certain term, provided with amusements and liquor, and thus kept apart from the influences of the vicious whites, who instigate them to crime in their "canteens," as the groggeries are called which are maintained by the I. D. B.'s. It became a question at one time whether the mines could be profitably worked, when from one-fifth to one-quarter of all the yield, it was estimated, never reached the proper owners, as the native diggers swallowed and concealed the diamonds in every possible way. It became necessary for the companies, in self-defence, to take extraordinary precautions against this great loss. Overseers or special searchers were appointed, who made the most thorough examination of all who left the mines. The natives use most ingenious methods for the concealment of the gems. On one occasion some officers, suspecting that a Kafir had stolen diamonds, gave chase, and caught up with him just after he had shot one of his oxen. No diamonds were found upon the Kafir, it is needless to say, for he had charged his gun with them, and after the disappearance of the officers, he dug them out of his dead ox. Diamonds have been fed to chickens; and a post-mortem examination a few years ago held over the body of a Kafir revealed the fact that death had been caused by a sixty-carat diamond which he had swallowed. Early in the history of the mines a detective force, consisting of men, women, and children, was formed, and the severest punishment is still inflicted on transgressors of the Diamond Act.

None but those authorized by the law, termed patented agents, less than fifty in number, are allowed to purchase or even to possess rough diamonds at Kimberley. The loss would not have been so great but for the irregular diamond I. D. B.'s, as the "fences" are called, who lowered the price of stones by underselling the companies in the London market.

More diamonds weighing over seventy-five carats each after cutting have been found since the African Mines were

opened, than were known before. The most important one found in South Africa is the Victoria diamond or Imperial diamond, as it is called. The original crystal weighed 457½ carats, or over three ounces Troy. Strange to say, although this is the largest diamond of modern times, its early history is very obscure. It is reported that the stone was found in the Kimberley Mines in the month of July, 1884, by a surveillance officer, and by him sold to some illicit diamond buyers, and afterward to a syndicate of European dealers. The stone has been cut, and in its finished condition weighs 180 carats. It is a beautiful, perfect, "steel-blue" diamond, and the largest white brilliant known, and is valued at $200,000. Among some other large diamonds may be mentioned the Du Toit, which weighed 244 carats when found; the Jägersfontain, 209¼ carats; the Stewart diamond, weighs 260 carats; the Tiffany yellow, weighing 125⅜ carats after cutting; the great Orange, 110 carats; the Porter Rhodes, weighing sixty-eight carats after cutting; the Dudley forty-six and one-half carats, and a number of others.

Thirty-eight million carats of diamonds, weighing over nine tons, have been found here. In the rough, their aggregate value was $250,000,000, and after cutting nearly $600,000,000, which is more than the world's yield during the preceding two centuries. Of the whole production, not more than eight per cent. can be said to be of the first water, twelve per cent. of the second water, and twenty-five per cent. of the third, while the remaining forty-five per cent. is called bort, a substance which, when crushed to a powder, is of use in the arts for cutting hard substances and for engraving. This must not be confounded with the bort carbon (carbonado) found in Brazil, an uncrystalline form of the diamond which from its amorphous structure is adapted for use in drills, for boring and tunnelling rocks, etc., and has never yet been found in South Africa. It is worth from six to ten times as much as bort.

An English company has recently been formed, under the name of the Hyderabad Mining Company, to work the mines in India, where it is thought that the famous Kohinoor diamond was found.

India and Borneo are now yielding very few diamonds, less than one per cent. in all of the entire product. These two countries, together with Brazil, yield probably less than five per cent. of the total output.

Diamonds have been found in the tertiary gravels and recent drifts near Bingera in Inverell, Australia; also along the Cudgegon River, 160 miles northwest of Sydney, and in other districts in Australia. The colors are white, straw, yellow, light brown, pale green and black. The largest stones yet found were cut into gems weighing three and one-half and three carats, respectively. A trial made by the Australian Diamond Mining Company produced 190 diamonds, weighing $197\frac{3}{4}$ carats, from the washing of 279 loads of earth. These Australian fields can scarcely be called productive as yet, nor from present appearances do they seem likely to become formidable competitors of the South African fields.

About twelve years ago, it was suggested by Messrs. Dunn, Cohen, Huddleston and Prof. Rupert Jones and others, that the South African diamonds were formed in a sort of volcanic mud. Mr. Huddleston thought that the action was hydrothermal rather than igneous, the diamonds being the result of the contact of steam and magnesian mud under pressure upon the carbonaceous shales; he compared the rock to a boiled plum pudding.

At a meeting of the Manchester Literary and Philosophic Society, held October 21, 1884, Prof. H. E. Roscoe presented a paper on the diamond-bearing rocks of South Africa, in which he said that he had noticed a peculiar odor, somewhat like that of camphor, evolved on treating the soft "blue" diamond earth with hot water. A quantity of this earth he powdered and digested with ether and on filtering and allowing the ether to evaporate, he obtained a small quantity of a strongly aromatic body, crystalline, volatile, burning easily with a smoky flame, and melting at about 50° C. Unfortunately, the quantity obtained was too small to admit of a full investigation of its composition and properties. He suggested that perhaps the diamond was formed from a hydrocarbon simultaneously with the aromatic body.

The late Prof. H. Carvill Lewis, at the British Associa-

tion Meeting, September, 1886, read a paper on the genesis of the diamond, in which he stated that from the DeBeer's Mine, at a depth of 600 feet, he had obtained specimens of rock which were unaltered, and proved to be a peridotite containing carbonaceous shale. He added that from information he had received from New South Wales, Borneo, and Brazil, he then believed that all diamonds were the result of the intrusion of a peridotite through carbonaceous rocks and coal seams.

The similarity of the South African peridotite to a peridotite, described by Mr. J. S. Diller, in Elliott County, Ky., led Prof. Lewis to suggest interesting possibilities there, and through the invitation of Prof. Proctor, of Kentucky, Major Powell sent Mr. J. S. Diller and myself to examine this Kentucky peridotite. Although the associated minerals were identical with those accompanying the diamonds, *i. e.*, of South Africa—pyrope garnet, ilmenite, biotite, pyroxene among others being present—yet by analysis of the enclosed carbonaceous shales, from which it was believed that the diamond is formed, it was found that the Kentucky shale contained only ·681 of carbon, while the South African contained thirty-five per cent., and could be readily ignited with a match. Hence, unless the peridotite has penetrated the older and richer Devonian shales, the probability of finding diamonds there has been considerably weakened by the investigation.

The occurrence of diamonds in the United States is chiefly confined to two regions, geographically very remote and geologically quite dissimilar. The first is a belt of country lying along the eastern base of the Southern Alleghenies, from Virginia to Georgia, while the other extends along the Western base of the Sierra Nevada and Cascade ranges in Northern California and Southern Oregon. In both cases, the mode of occurrence has several marked resemblances. The diamonds are found in loose material, among deposits of gravel and earth, and are associated with garnets, zircons, iron sands, monazite, anatase, and particularly with gold, in the search for which they have usually been discovered. This resemblance is due altogether to the

fact that these loose deposits, in both regions, are merely the débris of the crystalline rocks of the adjacent mountains and therefore present a general similarity, while the ages of the rocks themselves are widely different.

The finding of a twin crystal of diamond, weighing four and one-third carats, at Dysortville, N. C., of a three-carat stone near Atlanta, Ga., and of a three-eighths-carat stone at Montpelier, Adair County, Ky., are worthy of mention in connection with the finding of diamonds in the Southern States.

Ten years ago, $100,000 was an unusual amount for even the wealthiest to have invested in diamonds; whereas, to-day there are a number of families each owning diamonds to the value of $500,000. Ear-rings worth from $5,000 to $8,000 a pair excite no wonder to-day; formerly, they were seldom seen. Of the French crown-jewels sold in Paris, May, 1886, more than one-third, aggregating over $500,000 in value, came to the United States.

IMPORTS OF DIAMONDS INTO THE UNITED STATES.

From the customs import lists, after deducting the approximate value of cut stones other than the diamond, we find that import duty was paid on about $120,000,000 worth of cut diamonds in the last twenty-four years, of which $90,000,000 worth were imported during the last twelve years. In 1868, $1,000,000 worth were imported, and about $1,200,000 worth in 1867, but about $11,000,000 in 1888, and the same amount in 1889, or ten times as many in the latter year as twenty years previous, showing the increase of wealth and the great popularity of the diamond among Americans, the previous figures representing the import prices, exclusive of mounting or dealers' profits. A single firm at present sells yearly more than the annual import of 1867.

The expression "first-water," when applied to a diamond, denotes that it is free from all traces of color, blemish, flaw or other imperfection, and that its brilliancy is perfect. It is, however, frequently applied to stones not quite perfect, but the best that the dealer has, and they may be of

only second quality. It is almost impossible to value a diamond by its weight only. Color, brilliancy, cutting and the general perfection of the stone have all to be taken into account. Of two stones, both flawless and of the same weight, one may be worth \$600, and the other \$12,000. Exceptional stones often bring unusual prices, while off-colored stones sell for \$60 to \$100 a carat, regardless of size. The poor qualities have depreciated so much in value that some are worth only from one-tenth to one-fourth what they were worth twenty years ago. This is specially true of large stones of the second or third quality.

The names ruby, sapphire, Oriental amethyst, Oriental emerald and Oriental topaz are given to the transparent red, blue, purple, green and yellow varieties, respectively, of the mineral corundum. These colors are supposed to be due to the presence of minute quantities of metallic oxides. The specific gravity of corundum varies from 3·98 to 4·05; its hardness is nine. The finest pigeon-blood-colored rubies are found at Mandalay, in Burmah, and when fine command from five to ten times the value of diamonds of equal weight. Fine rubies, generally small, sometimes of a pink color, and often with a currant-wine or purplish tint, are found at Ratnapoora, Ceylon; likewise in Siam, where, however, the color is commonly a dark red, almost that of a garnet, and, like it, with a tinge of brown. The finest sapphires are found in Burmah and Ceylon; in the latter, some of the finest corn-flower blue varieties occur. Many of the rich velvety blue, as well as the lighter-colored stones are from the Simla Pass in the Himalayas. Fine sapphires have recently been found in Siam; and in Australia they occur of an opaque, milky-blue color.

Dr. William Crookes, after an elaborate series of experiments with all colors of corundum in sealed tubes, believes that the various colors are only modifications or allotropic forms of the same substance; and that since all the colors of corundum phosphoresce with the same range of colors in the phosphorescope, he suggests that there is no coloring matter.

The acquisition of the Burmese Ruby Mines cost the

British Government a vast sum of money. On the wars of 1826 and 1852 England expended $75,000,000 and $15,000,000, respectively; and after all this sacrifice of treasure the Burmah and Bombay Trading Company claimed, four years ago, that King Thebaw, of Burmah, had arbitrarily cancelled the leases by which the company controlled the output of the ruby mines near Mandalay.

The war of 1886, which followed, involved the raising of an army of 30,000 men and an outlay of $5,000,000, but the British Government gained control of the long-coveted ruby mines.

The question which next presented itself was, how should they be worked? Several firms were desirous of securing the lease, and after the Indian Government had virtually closed a lease to Messrs. Streeter & Co., the London jewellers, at an annual rental of four lakhs of rupees (£40,000) for a term of five and a half years, it was at first revoked, but after a time was given to Messrs. Streeter & Co., who organized the company known as the Burmah Ruby Mines (Limited), and sent a force of engineers and a quantity of machinery to Burmah. This year will determine whether or not the mines are as rich as they were supposed to be, and whether the ruby will still retain its place as the most costly of precious stones.

The ruby mines of Burmah are situated in the valley of Magok, fifty-one miles from the bank of the Irrawaddy River and about seventy-five miles north of Mandalay, at an altitude of 4,200 feet. Concerning these mines very little was known, as they were always the monopoly of the crown and were jealously guarded. It was said that they paid King Thebaw's Government 100,000 rupees per annum and one year 150,000 rupees. Mining was carried on by forty or fifty wealthy natives, who employed the poorer townspeople at liberal wages; but at present only seventy-eight mines or diggings are in operation. All the gems were sent to Ruby Hall, Mandalay, to be valued.

One thing at least we learned from the British occupation of Burmah, namely, that King Thebaw did not own the dishes of rubies which were said to rival anything known.

An examination of the jewels, now deposited at the India Museum at South Kensington, proved that there was only one cabochon ruby of fair, not fine quality, and several polished sections of a large inferior crystal of emeralds of any value in his entire crown jewels.

In 1882, a very remarkable discovery of sapphire was made in the Zenskar range of the Northwestern Kashmir Himalaya, near the line of perpetual snow. A landslide removed an abundance of sapphires which were first used as gun-flints by the natives. One writer speaks of having seen about a hundredweight of them in the possession of a single native. Traders, however, soon carried them to the distant commercial centres, where their value became known. There was an instant rush of jewellers' agents to the locality of the mine; and the price rose rapidly until about £20 per ounce was paid for the rough sapphires as found. The Maharajah, of Cashmere, promptly exercised his authority, and sent a regiment of Sepoys to take possession of the mines and harry the natives who were suspected of having stones in their possession or any knowledge of new localities where the gems could be found. Any one who had money was suspected either of having sold sapphires or of being about to purchase them, and was despoiled or even imprisoned. This naturally enough had the effect of compelling secrecy. Several crystals were found weighing from 100 to 300 carats each. During the first year of the discovery, the Delhi jewellers are said to have bought up sapphires to the value of £20,000.

The effect of this discovery was to lower the prices, for a time only, however.

Public interest in semi-precious stones has increased greatly during the last ten years. Formerly jewellers sold only diamonds, rubies, sapphires, emeralds, pearls, garnets and agates; but at present it is not unusual to have almost any of the mineralogical gems, such as zircon, asteria or star sapphire or star ruby, tourmaline, spinel or titanite called for, not only by collectors, but by the public, whose taste has advanced in the matter of precious stones, as well as in the fine arts.

This change may be partly attributed to the fact that since the Centennial Exhibition, art has received more attention among us than ever before. The Duke of Connaught's giving his bride a cat's-eye ring as an engagement token was enough to make that stone fashionable, and to increase its value greatly. The demand soon extended to Ceylon, where the true chrysoberyl cat's-eye is found, and stimulated the search for these stones there. In the chrysoberyl cat's-eye the effect is the result of a twinning of the crystal, or a deposit between its crystalline layers of other minerals in microscopie inclusions; so, that if the stone be cut across these layers *en cabochon*, or carbuncle-cut, as it is called, a bright line of light will be condensed on the dome-like top of the stone.

In the search for these chrysoberyl cat's-eyes, there has been found an endless series of chrysoberyls of deep golden, light yellow, yellow-green, sage-green, dark-green, yellowish brown and other tints. They are superb gems, weighing from one to 100 carats each, and rank next to the sapphire in hardness. It was a great surprise to the gem dealers to find that the darker leaf-green or olive-green stones possessed the wonderful dichroitic property of changing to columbine red by artificial light, which entirely subdued the green tint, and gave the red predominance. These were in fact alexandrites, stones which had formerly been found only in Siberia, and even there of but poor quality. Though found in large crystals, a perfect gem of even one carat was a great rarity. Here, however, were found fine stones, weighing four carats and upwards, and one exceptionally fine one weighing nearly seventy carats. These can be numbered with the most remarkable gems known. Strange to say, among this variety a few specimens have been found which combine the characteristics of both the cat's-eye and the alexandrite, and are called alexandrite cat's-eyes.

Moonstones, also from this same Province of Kandy, Ceylon, were brought to light by this search for cat's-eyes. It would not be an over-estimate to say that 100,000 of these stones have been sold here in the last four years. They

vary in size from one-eighth of an inch to nearly two inches in length, and many of them surpass anything hitherto known of their kind in beauty and size. Those that display the chatoyant and the opalescent blue color are especially beautiful.

The demand for cat's-eyes also brought into request the then rare mineral from the Orange River, South Africa, known as crocidolite, especially that variety that had been altered to a quartz cat's-eye or tiger-eye, as it is called. In this stone an infiltration of silicious water has coated each fibre with quartz or chalcedony, giving it the hardness of seven. This then pleasing stone readily sold for $6 a carat, and at the outset for even more: but owing to the excessive competition of two rival dealers, who sent cargoes of it to the London market, the price fell to $1 or even to twenty-five cents per pound by the quantity. Even table-tops have been made of this material by veneering. Vases, cane-heads, paper-weights, seals, charms, etc., were made of it and sold in large quantities. Burning it produced a bronze-like lustre, and by dissolving out the brown oxide-of-iron coloring, an almost white substance was obtained, which was dyed by subjecting it to the action of red, green, and brown-colored solutions, these colors, owing to the delicacy of the fibres, were evenly absorbed. A material unknown ten years ago is to-day found at every tourist's stand, whether on the Rigi, on Pike's Peak, in Florida, at Los Angeles, or at Nijni Novgorod, and sold under a variety of names, showing how thoroughly organized is the system of distribution in the gem market. Missionaries have never spread a religious belief as rapidly as traders have disseminated the tiger eye.

Since it has become generally known that Queen Victoria is partial to the opal, the old and stubborn superstition concerning it, which is said to date from Scott's "Anne of Geierstein," has been slowly yielding, until now the gem has its share of popular favor. During the last two years, ten times as many opals have been imported as were brought here during the preceding decade. Mexican fire. opals are much more common, as those tourists know to

their sorrow who buy these stones at exorbitant prices in Mexico, hoping thus to pay the expenses of the trip, until they find on reaching New York, that they are worth only about one-quarter of what they paid for them. The principal opal mines of Mexico are situated on the Hacienda Esperenza, near Queretera; and it is believed that a demand of 100,000 stones per annum could be supplied without raising the price perceptibly, though in the market of precious stones the demand generally raises the price.

The finest opals are from the mines of Dubreck, Hungary, which, although they have been worked for three centuries, still yield the government a revenue of $6,000 annually. The output is so carefully regulated that the market is never glutted. In Australia large quantities of opals have been found differing from the Hungarian and yet often quite as beautiful.

About ten years ago a new and very interesting variety of opal was brought from the Baricoo River, Queensland, Australia, where it is found in a highly ferruginous jasper-like matrix, sometimes apparently as a nodule and then again in brilliant-colored patches, or in specks affording a sharp contrast with the reddish-brown matrix, which admits of a high polish and breaks with a conchoidal fracture. Many of these stones are exceedingly brilliant. They are of the variety known as harlequin opals, their color being somewhat yellow, as compared with the Hungarian stone, although not less brilliant. The rich ultramarine blue opal in quite peculiar to this locality. A company (capital $200,000) has been formed, and the gems are about to be extensively mined. This stone is especially adapted for curious cameo-like objects, such as faces, dogs' heads, and the like, made by cutting the matrix and the opal together.

In 1877, F. Pisani, of Paris, described a transparent golden-yellow spodumene, which has been found in Brazil and was supposed to be chrysoberyl. Strange to say, a little later a yellow-green variety associated with emerald-tinted beryl crystals, the latter called "green bolts" by the farmers, was obtained by Mr. J. A. D. Stephenson, of Statesville, N. C., who brought it to the attention of the

northern mineralogists, Norman Spang, Dr. F. A. Genth and W. E. Hidden. The latter sent a specimen of this mineral, which he supposed to be diopside, a variety of hornblende, to Dr. J. Lawrence Smith, of Louisville, Ky., who found upon analysis that it was a transparent spodumene instead of diopside, as had been supposed, and named it Hiddenite. This locality has furnished several dozen crystals of the finest emeralds (of little value as gems, however,) that have ever been found anywhere. Among them is a crystal eight inches long and another weighing eight and three-quarter ounces, valued at $1,000. Both of these, together with many other fine minerals found here, are in the famous cabinet of Mr. Clarence S. Bement, of Philadelphia, the finest private collection of minerals in the world.

At Stoneham, Me., was found the finest aquamarine on this continent, weighing 125 carats, as well as many other fine stones, weighing in all some hundreds of carats. Some fine transparent yellow beryls were found at Albany, Me.; at the Avondale quarries in Delaware County, Pa., several twenty carats golden-yellow beryls and many smaller ones have also been found; and at a mica mine, near Litchfield, Conn., several thousand dollars' worth of this gem have been obtained. Amelia County, Va., and several localities in North Carolina have also afforded good specimens.

On Mt. Antero, Col., at an altitude of 14,000 feet, nearly on the line of perpetual snow, there have been found (associated with phenacite) some beautiful beryls, clear enough to afford a number of fine gems of good blue and green color.

In 1882, topaz was first found in Colorado, and since then it has been found in some abundance at Platte Mountain, Cheyenne and at Crystal Peak, near Pike's Peak. Many of the crystals are remarkable for their size, several of them weighing over a pound each. The smaller ones are transparent and range in color from pellucid white to rich cinnamon-brown. Some few are light blue and light green. The two larger gems weigh 125 and 193 carats, respectively, and equalled those from any known locality, but $3,000 would

probably be a fair estimate of the value of all that have been found there.

At Stoneham, Me., and at North Chatham, a town adjoining in New Hampshire, topaz, as well as phenacite, was found, the latter transparent enough to cut into gems. A few crystals of topaz, measuring one foot on a face, were also found, and a number of smaller ones, of little value as gems.

The Mount Mica Mining Company, of which Dr. A. C. Hamlin of Bangor, Me., is the organizer and President, began operations at the famous tourmaline locality, Mount Mica, near Paris, Me., in 1879, and prosecuted the work for three summers. There were found here very beautiful tourmaline crystals, and some of the finest known examples of this gem. A crystal of blue tourmaline, measuring nine inches, and a green tourmaline, ten inches long, were among the most remarkable finds, the proceeds of which altogether have amounted to something over $5,000.

At Auburn, Me., hundreds of crystals of tourmaline have lately been found, some of which have been cut into gems, though they do not approach in perfection those from the more famous Paris locality. In color, they are generally light green, light blue and light red.

Five years ago, the existence of rock-crystal of any size was almost unknown in the United States; but about that time, a large, clear mass, weighing some twelve pounds, which had been found in Alaska, was brought to New York City, and made into thin slabs for hand-mirrors. In 1885, a fifty-one-pound fragment, said to have been broken from a crystal which originally weighed 300 pounds, was found in Chestnut Hill Township, Ashe County, N. C. On visiting the locality, I found that most of the crystals there were obtained either by digging where one crystal had been found or by driving a plow until crystals were unearthed. Several dozen crystals in all have been found here, one mass of twenty pounds being almost absolutely pure. Some of the clearer masses have been cut into vindigrettes, bonbon boxes, clocks and other art objects and exhibited at the Paris Exposition.

Prof. R. B. Riggs, of the laboratory of the United States Geological Survey, recently made over twenty-five analyses of the tourmalines of all colors. He found the question of the color of the lithia tourmaline a very interesting one. The color of the iron and magnesian varieties depends on the amount of iron present, ranging from the colorless De Kalb variety through all the shades of brown to the Pierrepont black crystals, while the lithia tourmaline, containing more or less manganese, gives us the red, green and blue, as well as colorless varieties. The shades of color do not depend on the absolute amount of manganese present, but rather on the ratio existing between that element and the iron. Thus, when the amounts of manganese and of iron are equal, we have the colorless, pink or very pale green tourmaline. An excess of manganese produces the red varieties; and if the iron is in excess, there result the various shades of green and blue.

Turquoise, found in Los Cerrillos, N. M., where it had been worked for years before the arrival of the Spaniards, has recently been identified in Arizona, Colorado and Nevada. Although not of much value as an ornamental stone, it recommends itself for ornamental purposes.

The agatized or jasperized wood of Arizona, the existence of which has been known for thirty years, has only been utilized in the arts during the last four or five years. This material exists in immense quantities, in compact tree sections from one foot to four feet in diameter, and presents the most beautiful shades of yellow, red, brown, white and black, generally mottled, the colors all blending imperceptibly and thus producing a pleasing and harmonious effect. It has been successfully cut and polished by the Drake Company, of St. Paul, Minn., who saw and polish large surfaces of hard material better than can be done anywhere else. Its extreme hardness and its richness of color will always recommend it as a high-priced ornamental stone.

A curious white, opaque variety of opal, known as hydrophane, has been found at some Colorado localities. It possesses the remarkable property of displacing twice its bulk of water, and then from opaque white it becomes per-

fectly transparent. The finder proposes the name "magic stone," and suggests its use to conceal photographs, hair, or other objects which the owner wishes to display only as his caprice dictates. This stone is identical with one known as oculus mundi, world's eye, or lapis mutabilis, described by De Boot, De Laet, and Boyle, in the sixteenth century, and which was evidently tabasheer, an organic opal that forms in the joints of the bamboo. It is undoubtedly the snake-stone of the Buddhist priest. Tavernier, in his travels, states that the source of these stones was unknown, but says they clove to the roof of the mouth, and when dropped in water they caused the water to boil—in other words, air in bubbles would leave the stone and would ascend to the top of the water.

What may prove to be of considerable use in the arts, and as an ornamental stone, is the banded jasper, found in Graham County, Kan., which is beautifully banded like an onyx, in red, yellow, brown, white and other colors. Pieces a foot long, and six to eight inches thick, can be taken out. As a banded jasper, it is unrivalled in the whole world.

The small, brilliant rutile crystals from Alexander County, N. C., have furnished perfect black gems, which approach the black diamond more closely in appearance than anything else known.

The well-known labradorite rock of Lewis County, N. Y., is so plentiful that the reflection of the boulders has given the river that runs through the locality the name of Opalescent River. This is being extensively cut as an ornamental stone.

Pearls are lustrous concretions, consisting essentially of carbonate of lime interstratified with animal membrane, found in the shells of certain mollusks. They are believed to be the result of an abnormal secretory process caused by an irritation of the mantle of the mollusk, consequent on the intrusion into the shell of some foreign body, as a grain of sand, an egg of the mollusk itself, or perhaps some cercarian parasite. It has also been suggested that an excess of carbonate of lime in the water may cause the development of the pearl. Accepting the former theory as the

more probable one, it is easy to understand how this foreign body, which the mollusk is unable to expel, becomes encysted or covered as by a capsule, and gradually thickens, assuming various forms—round, elongated, mallet-shaped—and is sometimes as regular as though it had been turned in a lathe. It has been suggested that the mollusk continually revolves the enclosed particle in its efforts to rid itself of the irritation, and that this accounts for its roundness, and that the revolving is due to a natural motion which is accelerated by the intruding body.

In regard to the formation of pearls, the following statements may be made: Whatever the cause or the process of their production, these interior concretions may occur in almost any molluscan shells, though they are confined to certain groups, and their color and lustre depend upon those of the shell interior, adjacent to which they are formed. Thus, the pink conch of the West Indies yields the beautiful rose-colored pearls, while those of the common oyster and clam are dead white or dark purple, according to their proximity to the part of the mantle which secretes the white or the dark material of the shell. The true pearly or nacreous iridescent interior belongs to only a few families of the mollusks, and in these alone can pearls proper be formed at all, while, in point of fact, they are actually obtained only from a very few genera.

According to Dr. William H. Dall, none of the air-breathing mollusks (the land snails) produce a nacreous shell: and among fresh-water mollusks, none are pearl-bearers except certain of the bivalves, notably those belonging to the groups appropriately called the naiades, of which the common river-mussel (*Unio*) is a typical example. The soft internal parts of these mollusks are covered by a thin, delicate membrane, called the mantle, from the surface, and particularly from the outer edges, of which material is excreted to form the inner layers of the shell. The shell consists of two parts, the epidermis and the shell proper, the latter composed of numerous layers. The epidermis, which resembles horn, is chiefly composed of a substance called "conchioline," and is soluble in caustic alkalies.

[*To be continued*]

ELECTRICITY IN WARFARE.

By Lieut. Bradley A. Fiske, U.S.N.

[*A Lecture delivered before the* Franklin Institute, *January 20, 1890.*]

The Lecturer was introduced by Prof. Edwin J. Houston, and spoke as follows:

Members of the Institute and Ladies and Gentlemen:

About four years ago, a lecture was delivered before this Institute on the subject of "Electricity in Warfare." This evening, the endeavor will be made to present the present condition of the art, to show what advance has been made in the intervening years, in what ways electricity is now actually employed, and what is the direction of progress.

At the time of the previous lecture, November, 1885, nearly the whole science was in a transition stage; electricity was just emerging from the laboratory and entering the region of practical life; there was but one war-ship lit by electricity actually at sea, and her plant was so defective and accidents on board from imperfect insulation were so frequent that many concluded that the only effect of her electric equipment was to prove the impracticability of the attempt.

ELECTRIC LIGHTING FOR WAR-SHIPS.

Much of that lecture was devoted to maintaining the advantages of electric lighting for ships; now it will be unnecessary to do more than to say that every war-ship possessing any pretensions whatever to modern equipment is lighted by electricity.

SUBMARINE MINES.

As mentioned in my previous paper, the first practical plan for employing electricity in warfare was proposed and executed by Col. Samuel Colt, and embodied what is now called the submarine mine, or stationary torpedo. During the past five years it cannot be said that very much progress has been made in submarine mining, for it had then reached

a very advanced stage, so that it was practicable to lay out in any harbor a system of electric mines which could be relied upon to blow up any hostile ship trespassing on the premises, and to allow any friendly ship to pass without molestation. Defending a harbor with mines is simply carrying out with more or less elaboration a system by which a large number of water-tight tanks, holding from 100 to 1,000 pounds of gun-cotton or other explosives, are anchored in carefully defined positions and connected by electric cables with protected operating-rooms, in which are batteries, measuring instruments, etc. The more complete mines have usually floating above each of them an automatic circuit closer, in which two contact points are jarred together by a passing ship, and thus afford a passage for the electric current to the fuze in the torpedo. Ordinarily, this current is a weak one, sufficient only to close a relay in the operating-room, which sends in turn another current through a bell or other indicator, but not strong enough of itself to fire the torpedo. But when hostile ships are expected, then the relay is arranged to throw in a strong current, strong enough to heat the fine platinum iridium wire in the fuze, and ignite the fulminate of mercury. This fulminate detonates a primer of dry gun-cotton, and this, in turn, detonates full charge of damp gun-cotton in the torpedo.

SUBTERRANEAN MINES.

Closely related to submarine mines are subterranean mines, which have been used satisfactorily in land warfare, being sown in places over which the enemy might be expected to pass, especially in the approaches to a fort or other intrenched position. The mines may be fitted with percussion fuzes or with electrical connections, such that they can be exploded by an operator within the intrenchments, whenever the enemy arrives at the proper place. The result of the explosion of one of these mines in the midst of an advancing regiment cannot be pictured with comfort. The present system, in which troops are kept in open or skirmish line, rather than closed in mass, will prob-

ably result in a larger number of mines, each mine comparatively small.

SPAR TORPEDO

In my previous paper much space was given to the spar torpedo, in which the explosive was carried on the end of a spar, and was designed to be shoved against the underwater side of a hostile ship. Nothing need now be said about it, except that it is becoming rapidly a thing of the past; perhaps not rapidly enough.

LAY TORPEDO.

With the auto-mobile torpedoes, like the Lay, in which the directing-power, though not the motive-power is electricity, not very much change has come to pass; the torpedo occasionally is exhibited, and shows itself capable of doing good service under certain conditions.

SIMS–EDISON AND HALPINE–SAVAGE TORPEDOES.

In torpedoes, in which the motive-power, as well as the directing-power is electricity, considerable improvement can be seen, notably in the Sims-Edison and the Halpine-Savage. The principal difference between these two types resides in the fact that the power for the Sims-Edison is transmitted to it along the wire, while in the Halpine torpedo it is carried on board in storage batteries. The Halpine torpedo has additional features also, by means of which a projectile can be discharged from the bow, when it strikes any resisting object, such as the underwater body of a ship, or the projecting net, and by which this act of discharge reverses the propelling-motor, thus causing the torpedo to back away from danger. The projectile, meanwhile, keeps swiftly on its way, and when it reaches a certain distance, *i. e.*, the length of a small chain connecting it to the torpedo, it is exploded. The field for torpedoes of this class seems to be the coast, harbors and rivers of a country, rather than the open sea.

WHITEHEAD TORPEDO.

In the practical service of the far-famed Whitehead torpedo, of which there are probably more in existence than

of all others combined, it has been found that electricity gives a more precise control of the time of starting than any other means.

HOWELL TORPEDO.

In the Howell torpedo, which is rapidly coming into prominence as the superior of the Whitehead, it is now contemplated to employ electric motors to produce the rapid revolution of the fly-wheel, which stores up the energy needed for propulsion.

MILITARY TELEGRAPH SERVICE.

In armies, aside from submarine and subterranean mining, the principal use of electricity is in the military telegraph service, and its importance there can hardly be overestimated. One great cause for the suddenness and completeness of the German victory in 1870, was the rapid mobilization of the Prussian Army, and its appearance, on the frontier, ready for battle. Now the splendid efficiency of the telegraph service in the hands of the military authorities made this possible. Nothing is more essential in warfare than despatch and precision in moving the enormous bodies of men, of which armies are composed, with all their ammunition, equipments, supplies and numberless accessories. To move a quarter of a million of men to the frontier in one day means a great deal: and to manœuvre so large a body in the field, with such precision and rapidity that no one division shall have to wait for any other division, simply cannot be done without electricity. In military countries and in all countries during war-time, the regular telegraph lines are pressed into government service; but in the field, these lines must be supplemented by the military telegraph proper. This is a separate organization, with special duties and equipments. Carefully-designed wagons carry wires on reels, batteries, telegraph instruments, telephones, etc. Some of the wire is insulated, and is run rapidly along the ground, just as at a fire a hose is laid in a street from a rapidly-moving hose-cart, some of the wire is bare, is intended to be put on hastily-erected poles and on trees, sheds, etc., or sometimes to be simply laid along the

ground and used in connection with telephones, automatic circuit-breakers and telegraph keys. It is doubtless well-known to all here, that a telephone can be used in this way, even though it occasions a great waste of current, the telegraph key being manipulated in the ordinary way, and the automatic, circuit-breaker, causing a loud sound in the telephone whenever the key is closed.

BALLOON OBSERVATIONS AND BALLOON SIGNALLING.

As part of the military telegraph service, foreign armies have used balloon signalling considerably, and it will probably be an important factor in any future war. The movements of the enemy's forces can plainly be seen from a captive balloon at a height of (say) 1,000 feet, and the result of the observations telephoned down to the officers stationed on the ground. Balloons have also been used in signalling to a distance, an incandescent lamp being suspended beneath, which is made to glow at intervals and to thus signal letters and words in accordance with a preconcerted code.

BALLOON PROPULSION.

As regards balloon propulsion, many experiments have been made, notably by Tissandier, who has accomplished wonders in propelling balloons against the wind, using small storage batteries and very light electric motors. Nevertheless, it cannot be said that the advent of balloon propulsion can be seen anywhere upon the horizon of the future; while, at the same time, the rapid increase of speed and facility in travel, telegraphy, telephony and mail communication, is daily rendering ballooning more and more unnecessary.

INSPECTION OF GUNS.

Among the minor military applications of electricity, there are in use all over the world a number of such devices as small incandescent lamps arranged to illumine the bores of guns, velocimeters, etc., for inspection.

VELOCIMETERS.

Velocimeters are of countless forms, but in all, some kind of time-measuring instrument is set in motion by a

projectile striking one wire and stopped by the projectile striking another wire. The distance between the wires being known, the interval of time recorded is a measure of the velocity of the projectile while passing over that distance. In the same category is an electric chimograph, which records the exact instant a projectile starts and when leaves the bore.

ELECTRIC CONTROL OF WAR-SHIPS.

But it is in the modern war-ship that we find electricity in its broadest field. In no other equal space can there anywhere be found so many, so various and so important forms of apparatus. The reason is apparent. The modern war-ship is the most intricate, tremendous and powerful machine existing. The fate of a nation may, at a crisis, depend upon a single shot. Everything must be done to contribute to her speed, endurance and effectiveness. She must be under quick and absolute control at all instants. She must respond at once to the will of her captain, and her whole strength and power must be his, as though it were a part of him. Ensconced in his conning tower, he must be the brain of the gigantic body. Electric wires must, like nerves, convey instant tidings to him from her innermost recesses, and electric wires flash back from him the inevitable command. The enemy being in sight, the captain must, at each instant, know her exact distance and direction in order that he may lay his guns accordingly. These guns must not be apart from him, under only general control, but he must have them absolutely in his hand, and make them do his will. This does not mean that he must concern himself with details or himself press the key that fires the guns; his gunnery officer, a specialist, can do that; but the gunnery officer must have the proper apparatus under his personal direction, and fire the guns with the precision given him by his skill and experience, and the captain must personally direct the gunnery officer. As for the guns, they must always be bearing on the enemy, and always correctly elevated for the distance, so that they will be ready to fire as soon as they are loaded; no delay can be tolerated.

HANDLING HEAVY GUNS BY ELECTRIC MOTORS.

For quickly bringing heavy guns to point at the target, hydraulic machinery is usually employed in the navies of Europe. But in the U. S. S. *Chicago*, our newest and best cruiser yet at sea, one of the eight-inch guns is trained by an electric motor, and with gratifying results. The gun can be trained much quicker than by hand, but this is not the real element of superiority. The real element is the absolute control possessed by the gun captain. Ordinarily, he is forced to tell somebody else which way to move the gun and how far. With the best drilling and the coolest men, mistakes and delay occur; but with the present apparatus, the gun captain, or second captain, actually moves the gun himself, just where he wants it. Of course, no man is physically strong enough to accomplish this unaided; but the motor aids him almost without his feeling it. A small lever protrudes in rear of the gun, and this lever is so connected with a peculiar switch on the motor, that the gun follows the lever like an obedient child. If the gun captain wishes to move the breech of the gun to go to the right, he moves the lever to the right, as though it were really the gun itself, and the gun immediately moves to the right, slowly or fast, just as the lever moves; and when the lever stops the gun stops; the reverse operation occurs if the lever is moved to the left. It will be seen that this plan dispenses with any arbitrary motions, so that a person entirely ignorant of electricity can control the gun just as well as could Sir William Thomson. The nicest and smallest movements can be obtained, as well as the largest and most rapid, and the big gun, capable of throwing a 250-pound shell nine miles, carrying death and destruction with it, can be handled by a child.

ELECTRIC AMMUNITION HOIST.

But it is not enough that guns be handled with rapidity and precision; they must be supplied with a constant stream of ammunition. The problem of supplying ammunition with sufficient rapidity to carry on a modern engagement, is carrying to the front as one of the most important prob-

lems pressing for solution. The ammunition hoist now on board the *Atlanta* is a step in this direction, furnishing, as it does, a means for raising ammunition to the deck quicker than by hand, with greater safety and with fewer men, thus allowing the extra men to work at the guns. In this hoist, as in the gun-training apparatus, the same idea is carried out—*i. e.*, that of making the electric motor follow the motions of the operator's hand, both in direction and in speed. The operation of turning a wheel or crank causes the switch to start the motor in a certain direction, and the consequent motion of the motor operates to close the switch, so that a race ensues between the operator and the motor. If the operator begins to decrease the speed with which he turns the crank, the motor will overtake him, and will partially close the switch, and the motor will, therefore, lower its speed; whereas, if the operator increase his speed of movement, the switch will thereby be opened farther, and the motor will go faster. The advantage of this plan in the case of an ammunition-hoist will be apparent when it is stated, that the entire time required on board the *Atlanta* to raise a 250-pound shell is nine and a half seconds. Now, this interval gives a man very little time to think, especially in excitement or danger; and if the ordinary arbitrary movements for starting and stopping motors were employed, an accident would, some day, result from the wrong movement being made. Furthermore, with this device, if the operator is killed, or if he lets go the handle, or if, through excitement or confusion, he ceases to pay attention to the handle, or if a shot disables the motor, or breaks its connections—in all these cases, everything stops, and the shell simply stays where it is. This is a much better thing for it to do than to violently descend, or be forced up against the deck overhead, as would happen with any other device now known.

ELECTRIC MOTORS AS AUXILIARY ENGINES IN WAR-SHIPS.

The two plans above described comprise the only uses, besides ventilating, to which electric motors have as yet been put in ships. But in the near future, it is expected

that they will largely replace the many small steam-engines with which modern war-ships are filled. The most complete and detailed statement of the scope of motors for ship use is the lecture of Mr. S. Dana Greene, formerly an Ensign in our Navy, before the Naval Institute. Mr. Greene, from his training as a naval officer and his practical experience as Chief Engineer of the Sprague Electric Motor Company, is probably more intimately acquainted with the technical features of the case than anybody else. He states that for a ship like the *Chicago*, the auxiliary engines that could advantageously be replaced by electric motors are about forty or fifty in number, and aggregate about 200 horse-power. This estimate includes only those auxiliary engines which are at some distance from the engine and boiler-rooms, and which, at present, have to be connected to the boilers by very long, crooked and expensive copper pipes. Everybody here knows that a prime necessity in a war-ship is to have the pipes that convey steam, compressed air or hydraulic power, well below the water line: and everybody knows besides that a war-ship of to-day is made up of a great many water-tight compartments; and so it will need no great amount of explanation to give them an idea of the trouble, complication and expense of leading the numberless pipes through the water-tight bulkheads and around obstructions. How much easier, cheaper and safer to run wires! A wire can be bent and twisted to any extent, provided only that its insulating covering be not broken. Steam pipes, furthermore, always contain more or less condensed steam, or water, the amount varying with the conditions of the case; and the conditions existing with the long and crooked steam pipes of a ship are such as to cause the amount of condensed steam to be very great. Now this condensation, together with the friction, causes a very great decrease of pressure of steam in the engine cylinder and a great increase of back pressure; so that the steam and vacuum gauges in the engine-room convey no idea whatever of the state of affairs at an engine 200 feet distant. In other words, there is great loss of energy between the boilers and the engines situated at a distance

from them. But with the electric motor, we can certainly count on at least eighty per cent. efficiency, or at least seventy per cent. of the horse-power of the dynamo's engine, and this engine is itself very economical and is placed near the boilers. But more than all this, the simplicity, noiselessness and cleanliness of the electric motor itself stamp it as the ideal engine for ship use, when compared with the noisy, dirty steam-engine, with its joints, and valves, and stuffing-boxes and other features requiring incessant inspection.

SEARCH LIGHTS IN SHIPS.

At the time of my previous lecture, I endeavored to show the advantages of the search light for offensive and defensive operations. This would be unnecessary now, for these advantages are admitted. At that time, the great body of naval officers in all countries were skeptical concerning it, and very many of the most able officers laughed at it as a manifest absurdity, and stigmatized its advocates as those horrible monsters—theorists. Moreover, not a few official reports were made, which damned search lights with faint praise, calling in question their effectiveness and exaggerating their limitations. But, of late, the weight of professional opinion in their favor has become enormous, and the endeavor is now simply to find out the best way to use them, under the various phases of war. Let any one take his stand on the deck of a ship at night, knowing that an attack—even a sham attack—is to be expected; let him feel for a few moments the helplessness that is born of darkness; let him strain his eyes and his ears in vain to detect the faintest glimmer or the faintest sound to betray boats which he knows are somewhere stealing to the attack —then let the search light dart out its brilliant ray, and throw out into merciless distinctness every detail of some boat 1,000 yards away—swiftly and stealthily advancing—and he will need no subtle arguments to prove to him that the search light has come to stay. Of course, one must know how to use the light and when; one must not show it when he wants to keep his position secret from the enemy; neither must he use his steam whistle. But because a

device may be used disadvantageously, is no argument against using it advantageously. And it is a fact that in all the recent naval manœuvres abroad, the search light has been employed to a great and increasing extent.

SEARCH LIGHTS IN FORTS AND ARMIES.

But it is not only in ships that we find the search light. It is used in forts, notably those defending channels, to watch for attacking vessels, and for boats attempting to countermine; and many of the continental armies have wagons which carry boiler, engine, dynamo and electric light, for use in exploring battle fields at night and in searching for the wounded and the dead.

SEARCH LIGHT IN FOG.

A novel use of the search light was made one night on board the *Atlanta*, which was caught in a suddenly descending fog in a very dangerous position in shoal water. It was not deep enough to anchor with safety, in view of the heavy sea, becoming hourly more heavy with the increasing gale; and our position on the shoals was too uncertain to warrant an attempt to get into deeper water, lest we should get into shoaler water instead. The steam-launch was lowered, and an officer in it began to sound around the ship, to find a deep channel along which it would be safe to move. But the fog was so thick that it was soon found the launch could not go far enough from the ship, for fear of being lost. At this juncture, Lieut. G. A. Calhoun made the ingenious suggestion that one of the search lamps be lighted, and its beam turned in a certain direction, and the steam launch ordered to sound along the direction of this beam as far as it could be followed. The suggestion was adopted at once. It was found that the brilliant light illumined the particles of water suspended in the air to a surprising distance along a straight and narrow line. The launch would follow the ray as far as it could, sounding as it went, then return to the ship, following the guiding ray. This ray would then be turned in a new direction, and off the launch would steam, to prosecute its investigations along this line. In a few hours, a straight and deep channel

was in this way found, and with the little launch piloting the way a short distance in advance and piping its shrill directing whistle, the big ship slowly steamed out at midnight into deep water and a safe anchorage. "This was not warfare," it may be said. No, it was not; but it gives a pithy suggestion as to how in warfare, and under certain conditions, a ship could get out of a blockaded harbor under the friendly mantle of a fog; or how a man-of-war could, under such circumstances even enter certain harbors. Of course, it would not be prudent to attempt to so enter a a harbor filled with automatic electric torpedoes; but these weapons are so elaborate and expensive, that they cannot be used everywhere, and on many coasts, the main reliance must be placed on ships, shore batteries and torpedo boats.

Not only, however, are search lights of value in enabling us to discover an approaching enemy, they also enable us to see the silhouette of the gun sights on his illuminated surface, and direct the guns with precision on the darkest night.

In cases where it is not desirable to use the search light to illumine the target, a fine wire made incandescent by a current has been used with success to make visible the sights of the gun, which, of course, cannot otherwise be seen at night. The device is so good, that one is surprised that it is so seldom used.

AUTOMATIC SEARCH LIGHTS.

In this connection it may be here stated that there is a growing feeling in naval circles in favor of a greater number of automatic search lights, even if of small power individually, in order that all parts of the vicinity may be kept visible. Torpedo boats come so quickly, that one cannot afford to let any part of the horizon remain dark while a single beam on the broadside is making the rounds.

SEARCH LIGHT WITH VERTICAL BEAM.

A curious use of the search light has been experimented with, of late, and with interesting results. The lamp is so pivoted that its ray can be projected up vertically, thus

throwing a brilliant shaft of light like a silver arrow, high into the air. It is stated that this beam can be seen in a fog further than anything else can. The theory is that a fog does not exist except close to the surface of the water, and that the beam can be seen by looking up into air not much obscured by fog; so that, in other words, one does not have to look through so much fog to see this beam high up in the air, as he would to see the ship using the beam. As yet only small search lights have been tried, but they have been sufficiently successful to warrant the similar trial of larger lights.

RANGE FINDER.

It has been mentioned above as a prime necessity of effective gunnery at sea, that the gunners shall know at each instant the exact distance of the ship at which they are to shoot. To realize this, we must reflect that, if two ships are approaching each other at the rate of even twelve knots each, their distance apart is changing at the rate of thirteen and one-third yards per second. This means that in less than four seconds, the distance, or range will change fifty yards, which represents the distance apart of two consecutive graduations on the sight-bar of a modern rifled gun. In other words, the sight-bars of high-powered guns are usually graduated to fifty yards, and it is necessary for effective shooting that an error as great as fifty yards must not be made in estimating the distance, and timing the discharge of the gun, as the ship rolls from side to side. But if this change of fifty yards is made in four seconds, we see that we must have an instrument which will give the range with less than four seconds delay, and give it at the very least with less than fifty yards error. Such an instrument is called a range finder. It may be objected that, if you close with your enemy to "point blank range," as it used to be called, or say about 500 yards, then you can fire away as fast as you please, and the flight of the projectile is so nearly horizontal, that you do not need to know the range. This is perfectly true, but it should borne in mind, that, if the enemy's ship has a range finder, he can begin at 2,000 yards at the least to deliver a careful and accurate cannonade

with heavy shell, and inflict tremendous damage on you while you are waiting for close quarters. Moreover, as soon as he discovers that you want to close, he will at once, and for that reason, try to defeat your plan and keep you at a distance, all the while pouring in his merciless fire.

Perhaps a few words of description of the newest range finder will not be out of place, especially as it has a number of features interesting from a scientific point of view. All know that every calculation of distance depends upon solving a triangle, in which a base line is known, and two angles at its ends are measured, these angles being included between the base line and lines drawn from its ends to the distant object. In surveying, theodolites are placed at the ends and the angles are read from their graduated limbs. In this range finder, a german-silver resistance wire replaces the graduated arc, while a receiving instrument, which is in fact a rheostat, sums up automatically the angles. The base line being a constant, the receiving instrument is marked in yards at once, instead of in angles. The operation of using the range finder then, is this—two observers at opposite ends of the base line, gaze continuously at the distant object using telescopes preferably. They do nothing else; but a third observer, watching a galvanometer, simply moves a contact bar along a resistance wire on the receiving instrument in such a manner as to keep a galvanometer needle always at zero. His contact bar then points at the correct distance. If the object be moving, it makes no difference; the operation is as easy as if the object were stationary, and the indications are instantaneous and continuous. With a 290-foot base line on board the U. S. S. *Chicago*, one instrument being mounted in the bow and one in the stern, the average error in the official trial was six-tenths of one per cent.; and no difficulty was found in continuously reporting the distance of moving vessels.

POSITION FINDER.

Closely related to range finding, is position finding, in which not only the distance of an object is obtained, but its exact position. It has been the practice in the forts of all

nations to divide the harbor or other adjacent water, into imaginary squares about 100 yards on a side, these squares being marked on a chart and numbered. Somewhere within or near the fort is a carefully measured base line, and at its ends, are two telescopes, or alidades, connected together by telephone, telegraph, step-by-step apparatus, or other means. At some sheltered spot is the chart above-mentioned, over which two pointers are arranged to sweep, being pivoted at the points representing the two telescopes. Now, if the observers at the telescopes keep the officer at the chart constantly advised as to how their telescopes are pointing, he simply moves his pointers to correspond, and the intersection of the pointers on the chart represents the object at which the two telescopes are directed. Noting the square upon which the pointers intersect, the officer telephones or otherwise signals to the guns to fire at square 110, 125, etc. Then the officers at the guns train and elevate their guns so as to fire into those squares, having at hand tables to direct them how to so train and elevate. It will be observed that guns can thus fire at a target when the smoke at the guns is so thick that the gunners cannot see the target. But Major Watkin, of the Royal Engineers, has improved upon this method, and very greatly. The details of his invention are guarded strictly, but some of the results are known. They are simply diabolical. Gunners who could not see a target, and did not know how far off it was or where it was, have put forty-four per cent. of hits on the deck of an imaginary iron clad at ranges of from 3,000 to 4,000 yards, or from one and three-fourths to two and one-half miles. Perhaps in the course of a few months we shall hear of a position finder invented nearer home.

All the guns of a fort can be fired with marvellous accuracy by an officer distant from the smoke, noise and confusion of the battery, but connected with observing stations so located as to command a good view of the vicinity.

FIRING GUNS BY ELECTRICITY.

A very great increase in the accuracy of gunnery at sea is secured by the plan now coming into use in all civilized

navies, by which the guns are discharged by electricity. The general idea is not new, but it is only of late that it has been made thoroughly practicable. By the old plan the gun captain ordered "right" or "left" and the sailors hauled the gun to the right or the left; or he ordered "raise" or "lower" and the sailors raised or lowered the breach of the gun. When he got the gun nearly right, the gun captain called "ready," and everybody got clear of the gun in order not to be injured by the recoil. When the motion of the ship brought the gun sights in line with the target, the gun captain pulled lustily on his lanyard, and the gun went off. But under the new system one of the sailors moves a small lever to the right or to the left, as explained above, so as to keep the gun pointed all the time in the direction of the target. The gun captain holds a small circuit-closer in his hand, and as soon as the rolling of the ship brings the sights level with the target, he simply presses his fingers, without bothering himself to see if the men are away from the gun, because the recoil will not hurt them. Knowing the exact range, and having this quiet and simple means literally at his fingers' ends, what is to prevent a gun captain from hitting the target? It must be borne in mind that the real errors in shooting at sea, are not in shooting to the right or the left of the target, but in shooting over it, or short of it. This shooting over or short arises from two things: first, having a mistaken idea of the distance; second, firing too soon or too late when the ship is rolling. Now a range finder eliminates the first error; and electric firing goes a great way towards eliminating the second error, principally because it obviates the necessity for making any allowance for delay in the firing of the gun after the gun captain has done his part. Electricity discharges a gun at the instant when the gun captain presses his fingers and not at some other time. So that if a gun captain, having his gun set at the correct range, presses his fingers when the sights are in line with the target, he will hit the target. Of course, errors of eyesight cannot thus be eliminated, neither can the errors of the gun; but both of these are both exceedingly small, so small compared with the other errors, that they are inconsiderable, as has been abundantly proved.

MARINE PROPULSION BY ELECTRICITY.

The question is often asked: "Is marine propulsion by electricity one of the probabilities of the future?" The only way to answer this query, is to decline to attempt the *rôle* of the inspired prophet, for while one would not have the hardihood to say that it will never be (remembering the solemn promise of a celebrated English scientist to *eat* the first steamer that should cross the Atlantic), yet on the other hand one would hardly dare to assert that it will be. The question is merely one of practicability; at present electric marine propulsion is not practicable, except on a small scale, but the difficulties in the way are of the nature often overcome by persistent experiment and by the improvements resulting from slow experience.

ELECTRIC LAUNCHES.

It can be definitely stated, however, that electric launches are so near a practical success that one does not need to be a prophet to discern their coming in the near future. No less an authority than Prof. Geo. Forbes declares that they are already a practical thing on the Thames for a certain class of boats, in which great speed is not essential, but in which quiet, easy motion and cleanliness are desirable. He further states that, in his boat, he has got a return of nearly sixty per cent. of the horse-power put into the storage cells in absolute power of the propeller. Some of the storage cells now in the market are quite durable, if not over-discharged or shaken up. I have a battery of thirty cells, of the size known as 7 M, which have been used in developing the range or position finder mentioned above, and they have fulfilled the purpose exactly. They were originally charged last July, and they did not have to be recharged until a month ago. They were used on board the U. S. S. *Chicago* for some months, and were subjected to a good deal of rough treatment, being moved about the decks a good deal, lowered down into a store-room and hoisted up on deck again a number of times; besides this, the sailors spit tobacco juice on them, and then played salt water on them with a hose, to wash them. The sailors

called the case containing the cells the "box of electricity." At first they looked at it with the contempt which every true man-of-war's man feels for anything scientific: but they generally acquired for it a certain respect, as time went on, and they saw what curious things the ugly black box could do.

One of the newest electric launches is *The Magnet*, 28 feet long and 6 feet beam, drawing 2½ feet of water. She carries fifty-six accumulators, weighing 2,400 pounds, or about as much as fifteen men, and these accumulators furnish the energy to drive an electric motor whose armature is on the same shaft with the propeller. It is claimed that this boat can carry twenty people in smooth water, and that she can go eighty miles at a speed of six to eight knots, or go a shorter distance at a speed of eight to ten knots. It would seem as if, even at the present stage of development, such a boat would be valuable in a war-ship, from the fact that it can be got ready for service instantly, and can go faster and longer than an ordinary man-of-war's boat, pulled by oars.

ELECTRIC PICKET BOATS.

It could do excellent work, for instance, in case of a fleet at anchor, in carrying despatches from ship to ship. The cells in the boat could be charged while the boat was lying alongside, or even when hanging at the davits; and in such emergencies as are constantly occurring in naval life, it could be lowered and started off in a few seconds; while for scout duty or lookout duty, what other boat could be so noiseless and swift?

ELECTRIC SUBMARINE BOATS.

Closely allied to electric launches are electric submarine boats, in which also the energy needed for propulsion is carried in storage cells. The newest vessel of this class, about which much is known, is the Spanish submarine torpedo boat *Peral*. Trustworthy details are hard to get, but there seems to be no doubt that she can remain under water for hours, can move at a high speed both above and below water, and that she can carry enough energy in the

storage cells to enable her to carry out any attack which a submarine boat is intended to make, *i. e.*, a sortie from a harbor upon an attacking fleet.

ELECTRIC COMMUNICATION BETWEEN SHIPS AT SEA.

I fancy that everybody here is aware of the fact that the great need of all navies is a quicker and more trustworthy means of communication between ships at sea. Doubtless, most of you know also that many experiments have been made looking to the establishment of a means of communication by electricity. Two general lines of experiment have been followed. In one, sound vibrations are set in motion in the water, and are received on a diaphragm, usually on the under water side of a ship, this diaphragm corresponding to a telephone transmitter, the receiver being in the pilot-house, or other convenient place. The other line, contemplates sending electric signals through the air or the water, the receiver being usually a telephone receiver. During about two years, a great many experiments were made at the New York Navy Yard in the latter line, signalling both through the air and through the water. These experiments were on a pretty large scale. A large dynamo was used as a source of power, and in one case the U. S. S. *Atlanta* was converted into the largest electro-magnet known, being wrapped with heavy wire, through which the dynamo current was sent, while the iron tug *Nina*, 150 feet long, was made a receiver, she being wrapped with fine wire having a telephone in circuit. But the most satisfactory results were got by sending the impulses through the water; and though nothing quite practical was reached, yet one felt all the time that it was because he was not prosecuting the experiments correctly. These experiments seem worthy of mention, because they indicate one of the few fields of electrical engineering not yet explored.

ELECTRIC SIGNALLING.

But electric signalling by lights is already a practical thing, and is used in all navies. It is not the ideal thing, and does not attempt as much as the plans above-mentioned. But it is a great improvement on the old plans,

and can do good work with skilled operators. The plan most employed is to make and break the circuit of incandescent lamps, and thus signal letters and words according to a preconcerted code. But when distant signalling is desired, between points ten miles apart, for instance, or when high land intervenes, then the penetrating ray of the search light is flashed into the sky.

In conclusion, if we compare the art of electricity in warfare at its present stage with that prevailing five years ago, and we shall see that a comparatively unimportant thing has grown to be an important thing, and that scientific apparatus is employed much more than it was then.

NECESSITY FOR EFFICIENT EQUIPMENT OF WAR-SHIPS.

Now this indicates the tendency in modern warfare; a tendency to accomplish a desirable end by any effective means, no matter how complex or how expensive. Certain objects must be attained. If a ship is to go into a fight, she must whip. A lost battle is a national regret forever. A single ship, a small one perhaps, like the *Kearsarge* may fight a battle, and of which the consequences will be altogether out of proportion to the money value of the ship. There are thousands of buildings in this country that cost more than did the little *Kearsarge;* but suppose this cheap little ship had been sunk by the *Alabama.* The thought is unendurable. Now every nation feels that each of her ships is an exponent of what she can do in that tonnage, and while no nation feels bound to build ships, each one of which can whip any ship in any other navy, she does feel bound to build and equip each ship well enough to whip any foreign ship of her size and weight. So modern ships are coming to be the foremost examples of the application of science to practical things.

TENDENCY OF MODERN WARFARE.

The sailor is still a sailor, and will always be a sailor, so will the soldier always be a soldier. The profession of arms, whether on land or sea, calls for and develops certain qualities of mind and heart. Endurance, decision and chivalric courage will win battles in the future, as in the past. The

grand principles of strategy persist, and so do the laws governing the command of men. Yet the *conditions* of warfare are changing. Simplicity is giving place to complexity. Woe to that nation which fails to note the signs of the times. War is a serious thing, but it is more serious to the vanquished than to the victor. It behooves every nation to see that by no chance shall it be vanquished. No means of offense or defense must be neglected, because it seems too delicate or too expensive, provided only that it can be made to be efficient. Science is daily coming more into our lives, as the number of those who study her increases; but in no department of life is she making more progress than in warfare; and in warfare no branch of science is making more progress than electricity.

On SCHOOLS: with PARTICULAR REFERENCE to TRADES SCHOOLS.

By Joseph M. Wilson, A.M., C.E.
President of the Franklin Institute.

[*Continued from vol. cxxx, p. 144.*]

Herr Kjennerud, after completing his description of the method of instruction adopted at Fredrickshald, goes on to say, that "it has been maintained with great force and with much justice that hand-work does not have its full rights unless it is regularly incorporated in the school course, and receives such treatment that it may exert an educating influence on the child, inasmuch as, like modelling and drawing, it aims to develop the pupil's eye, and his sense of form and of beauty." "Therefore it should have an acknowledged place, in the higher as in the lower schools." Hand-work "may certainly very easily be somewhat overrated as positively refining, and some may in a great measure, fail to look at its practical side." Hand-work, however, "can scarcely be ranked too high as a link in the true education." It is not necessary here "to consider its significance as to moral training, but if we start with the

idea, which has already been acknowledged, that schools should impart such skill to female children as every child should possess, so ought the public school to give instruction to boys in the use of the hands, so that every man, to whatever station he belongs, shall have acquired such power that he may not stand helpless in any occasion of life, in consequence of a one-sided education; then a path will have been broken by which to arrive at a method in which the school must work."

Herr Kjennerud further says that "the exercises should begin with the handling of the tools most often used in daily life, as for example the knife, axe, hammer, plane, saw, file and possibly the paint brush." "The chief importance must be attached to joiners' work for the reason that he who understands how to handle joiners' tools will have little difficulty with other simple work." "Although turning will train the eye and the sense of form and symmetry, it must still take a subordinate place, particularly where there are not the means to procure the necessary tools." "A little wood-carving can be practised, not only because it serves in a high degree to cultivate and refine the taste, but a little experience will enable one to produce tasteful pieces of work for his own recreation."

"Whittling should not be neglected, as the knife is a tool for the use of which many opportunities will be found at home."

"Whether basket-making should have a place in school is exceedingly doubtful." The material is one that will easily take any required form, the work can be made instructive, and articles for both use and ornament can be manufactured; but much practice and strong hands are needed; the work is of inferior strength and durability; the material cannot be procured in many places, and "it cannot be maintained that exercises in basket-making have a general value."

"Painting, particularly of manufactured articles of wood, appears quite suitable for work-schools." A short course in smith's work and practise in the use of the file, would be advisable, and in many cases a forge is not necessary. Tin-

plate work is less necessary, although a knowledge of soldering often comes into use and is quickly learned.

"It can hardly be allowed that shoemaking is of great importance as a means of cultivation. The position required during work is by no means the most suitable for bodily development. It is stated that the medical council of Dresden, Germany, for this reason expressed themselves against its introduction as a school branch." "Still, skill in mending shoes is so important for people of the working classes, both economically and on sanitary grounds, that its place in school may be said to be justified on this account, which cannot be said of tailoring, for which the boys have shown no liking."

"Bookbinding is hardly of practical importance, except for those schools in which there are children in whose homes there are books to bind."

"The work to be carried out should be particularly limited to actually useful objects, and such as do not lie above the pupil's power to make with little assistance. It should be customary for the pupil, as far as possible, to be self-helping, and he should not be deprived of the satisfaction and encouragement to diligence and perseverance, which are always sure to follow when one has accomplished a piece of work with only his own help." "And that there may be opportunity for the development of taste and a sense of beauty in work, when procuring models, the coarseness and ugliness which often characterizes the work of schools should be avoided."

One further extract from Herr Kjennerud's remarks will be sufficient for our present purpose. He states that "a plan derived from any other fundamental principle than that the school is for life in general, will very certainly lead astray, as has happened," in his opinion, "in some places in Sweden, where a disproportionate number of hours has been assigned to hand-work, even as many as half the whole time of instruction." "With three to six hours a week obligatory hand-work, running through two or three years, any reasonable demand would appear to be satisfied."

THE DEPARTMENT OF SCIENCE AND ART OF THE COMMITTEE OF COUNCIL ON EDUCATION, LONDON.

The Department of Science and Art was established in connection with the Board of Trade in March, 1853, as a development of the Department of Practical Art, which in 1852 had been created for the reorganization of schools of design, and it was placed under the direction of the Committee of Council on Education in 1856.

The head of the Department is the Lord President of the Council, and he is assisted by a member of the Privy Council, who is called the Vice-President of the Committee on Education, who acts under the direction of the Lord President, and for him in his absence.

A sum of money is appropriated annually by Parliament for the promotion of instruction in science and art in the United Kingdom, especially among the working classes, and it is administered by this Department. It is applied to the maintenance of the science and art museums at South Kensington, in Dublin, and in Edinburgh; of the Normal School of Science and Royal School of Mines and the National Art Training-School at South Kensington; of the Royal College of Science and the Metropolitan School of Art in Dublin, and to aid in the establishment and maintenance of local schools and classes for instruction in science and art and of local museums of science and art.

The aid is granted in the form of—

(1) Payments to the committees of schools and classes, on the results of instruction, and certificates, prizes, medals, free studentships, scholarships and exhibitions to the students.

(2) Building grants, and grants for the purchase of apparatus, examples, fittings, etc.

(3) Aid to teachers and students in attending the Normal School of Science and the National Art Training-School, South Kensington; the Royal College of Science, Dublin, and other approved centres.

(4) Loans and grants to local museums and to science and art schools.

(5) Aid to training-colleges for instruction in science and art, and to elementary schools for instruction in drawing.

The schools and classes must be those approved by the Department and they must be open at all times to the visits and inspections of its officers.

The Department is the sole judge as to grants and awards, and they may be withheld wholly or in part for any breach of the rules.

The appropriation funds depend upon the action of Parliament, and are liable to be decreased and eventually discontinued. There is, therefore, no guarantee that they will be perpetual, and it is particularly impressed upon those who benefit by them that they must not be considered as in any way establishing a claim to any payments beyond those offered from time to time. The payment of fees by students must be looked upon as essential to the maintenance of a proper system of instruction, and though at present this is not made an absolute condition of the grants, yet gratuitous instruction is only permitted exceptionally and in those places where schools or classes have but recently been established, or it can be shown to the satisfaction of the Department that the circumstances of the locality justify this relaxation of the rule.

The standard of fees must necessarily vary in different localities according to the rate of wages and other circumstances, but committees of schools should fix as high a rate as they consider can fairly be imposed and they must certify annually to the fees received. No school or class is permitted to charge abnormally low fees in order to compete with the others in the same locality. The committees of the various schools and classes are expected to fix together some minimum fee for the district.

Students of a training-college, pupils of an elementary school who pay the regular fees of that school, pupil-teachers in elementary schools, art pupil-teachers and holders of free studentships may be exempted from fees.

Every science or art school or class must be under the superintendence and management of a local committee, who engage the teachers, are generally responsible for it, and

conduct, or assist in conducting, the examinations. The committee are also responsible for all apparatus, fittings, etc., towards the purchase of which the Department has granted aid.

There are a number of rules governing the formation of a committee. It must be composed of a chairman, secretary; and at least three other members, as many persons as possible in recognized positions of public responsibility in the district being placed on the committee.

A regular series of forms and instructions are provided for guidance in establishing and maintaining schools and classes. Each school or class, as formed, is assigned a distinguishing "school number," and every year a new application form must be returned to the Department on or before October 31st, a deduction of half a crown per day being made from the next payment to the school for each day's delay in sending the return beyond that date. Annual reports must be sent in from each school or class. In certain cases the Department will permit the organization of a committee for the purpose of conducting examinations of a school or class which receives no grants.

It will be noticed that the aid granted by the Department is intended only to supplement, not supersede, local effort. The local committee is obliged to provide and maintain suitable rooms for the classes, etc., and if at any time these appear unsatisfactory or insufficient, or if there is reason to believe that the instruction or supervision is inefficient, the assistance of the Department may be reduced or withdrawn.

A grant may be made, under certain specified regulations, in aid of a new building, or for the adaptation of an existing building, for a science or art school, at a rate not exceeding 2*s.* 6*d.* per square foot of internal area, up to a maximum of £500 for any one such school.

Grants are also made for fittings, apparatus and examples, under certain regulations, to an amount not exceeding fifty per cent. of their cost, and there are special rules for endowed schools. The Department has a lien on all objects purchased with its aid, one-fifth of which determines with each

year of actual use, and after five years the objects become the property of the committee.

Teachers are required to be qualified in accordance with certain examination rules, and the class in each subject of science, or group of subjects of art, must meet under the instruction of a qualified teacher, on at least twenty-eight days during the session, each meeting being of at least an hour's duration.

Every school or class is obliged to make an annual return before October 1st of its teaching staff and time-table of instruction for the current session, and in case of an old school or class, the statistics for the past session.

The examinations are of two kinds, personal and examinations of works. The personal examination of students in science and art are held annually about May, and of training-colleges about October and December. The May examinations are open to external candidates. The examination of works commences in April, the works being sent to the Department for that purpose.

There are certain rules and regulations, which need not be detailed here, for the conduct of examinations, for arrangements for local examinations, for applications for examination papers, for the custody of such papers, to prevent the possibility of any tampering with them, and for re-examinations.

Payments are made to local committees on the results of instruction as tested by the examination of students, on condition:

(I) That the teacher is qualified under the regulations.

(II) That the teacher has given at least twenty-eight lessons during the session on the subject of science, or group of subject of arts, on which payment is claimed.

(III) That each student, on account of whom a claim is made, belongs to one or other of the following categories:

(*a*) Persons in the receipt of weekly wages, and their children if not gaining their own livelihood.

(*b*) Teachers and pupil-teachers of elementary schools in connection with the English or Scotch Education Departments, or the National Board of Education in Ireland, and their children if not gaining their own livelihood.

(*c*) Persons in the receipt of not more than £200 per annum from all sources, and their children if not gaining their own livelihood.

(*d*) Scholars in Public Elementary Schools within the meaning of the Elementary Education Acts.

(*e*) A member of a *bona fide* night class for industrial students, which meets after 6 P.M., or on Saturdays, after 2 P.M.

(IV) That each student on account of whom payment is claimed in any subject, has received twenty lessons, at least, in that subject of science—or in art in the requisite group of subjects—and that the attendances have been duly registered.

(V) That all such attendances have been made within the two years immediately preceding the examination on account of which the claim is made, and under the supervision of the same committee.

It is not deemed necessary to give here the details or amounts of the payments that are made. Medals, prizes, certificates, scholarships, etc., are awarded to students on results of examinations. There is quite a large list of these awards, which are often of very considerable value, and naturally act very effectively as incentives to study and improvement.

Grants are made to aid local efforts in founding scholarships and exhibitions, these grants, however, being only made on the condition that the scholarship or exhibition is awarded on the results of a competition, and that a sufficient sum is provided for the special purpose of the scholarship or exhibition, by the voluntary contributions of living persons.

In reference to the science and art scholarships, these must be awarded in competition among the pupils of any elementary school or schools not conducted for private profit. The object of the scholarship is to enable the committee of the local fund to maintain the successful competitor, while pursuing his studies, for one, two or three years, at a day-school approved by the Department.

The managers of the local fund must contribute £5 each year to the Department before April 5th, and this

local contribution will be supplemented by the Department with a grant of £4 for the first year; £7 for the second; and £10 for the third year. It will rest with the locality, however, to decide whether the scholarship shall be tenable for one, two, or three years. There are certain conditions governing these scholarships.

In reference to local exhibitions, the Department makes a grant of £25 per annum to the managers of the local fund, who raise by voluntary subscription, and furnish before the fifth of April the like sum for the maintenance of a student at some college or school where a thorough course of instruction in science or art of an advanced character may be obtained. His whole time must be devoted to instruction, and there are certain conditions to be observed in making the award.

Great liberality is shown in granting free admissions to museums and libraries to students, teachers and other persons of certain classes and conditions.

Grants are allowed in aid of the purchase of objects for museums in connection with schools of science and art, or established under the Public Libraries Acts, or otherwise under a municipal governing body. These grants are primarily intended to assist local museums in obtaining reproductions in plaster, or by the electrotype process, or by photography; but they are not absolutely limited to reproductions. They may be made for the purchase of original objects of art or science, but in considering applications preference is always given to those for reproductions. The objects must be approved by the Department of Science and Art; no grant will be made toward the carriage of the objects, and no object on which aid has been granted can be sold or exchanged without the permission of the Lords of the Committee of Council on Education.

Collections of objects of science and art are loaned for a short period of exhibition to schools and for an extended period to permanent museums, either at schools or established under the Public Libraries Acts or under municipal authority. Exceptional loans are also made where no schools or museums exist, provided always that the proceeds

of the exhibition are used to further or establish a school of science or art or a municipal museum.

The museums and libraries at South Kensington contain objects, books, drawings, etc., illustrative of, and apparatus for, teaching the following subjects:

Machine construction,	Chemistry,
Building construction,	Animal physiology,
Naval architecture,	Botany,
Theoretical mechanics,	Navigation,
Sound, light and heat,	Steam,
Magnetism and electricity,	Physiography,
Principles of agriculture,	

and the following branches of art:

Sculpture in marble, stone, etc.	Enamels on metals,
Mosaics,	Pottery and porcelain,
Carvings in ivory, bone, etc.,	Glass vessels,
Woodwork,	Stained glass,
Metal work,	Leatherwork, including book-binding,
Coins and medals,	Textile fabrics,
Arms and armor,	Lace,
Silversmith's work,	Musical instruments,
Jewelry,	
Decorative paintings.	

Apparatus, paintings, drawings, etc., are lent to schools of science and art, for purposes of study under certain conditions, these loans being of two kinds—the deposit loan, the objects being left for considerable periods; and the temporary loan, usually made for a time of twelve weeks, which under certain circumstances, may be extended.

REGULATIONS SPECIAL TO SCIENCE.

Aid is given towards instruction in the following subjects of science:

(1) Practical, plane and solid geometry.
(2) Machine construction and drawing.
(3) Building construction.
(4) Naval architecture.
(5) Mathematics.

(6) Theoretical mechanics.
(7) Applied mechanics.
(8) Sound, light and heat.*
(9) Magnetism and Electricity.*
(10) Inorganic chemistry (theoretical.)
(10p.) Inorganic chemistry (practical).
(11) Organic chemistry (theoretical).
(11p.) Organic chemistry (practical).
(12) Geology.*
(13) Mineralogy.
(14) Animal physiology.*
(15) Botany.*
(16), (17) Biology including animal and vegetable morphology and physiology.*
(18) Principles of mining.
(19) Metallurgy (theoretical).
(19p.) Metallurgy (practical).
(20) Navigation.
(21) Nautical astronomy.*
(22) Steam.
(23) Physiography.
(24) Principles of agriculture.
(25) Hygiene.

Each subject is subdivided into three stages of courses—the elementary, the advanced and honors—except mathematics, which is subdivided into seven stages, with honors in three groups of stages.

In the subjects marked with an asterisk there may be a practical as well as a written examination in honors.

The laboratory of a science school must be devoted wholly to practical work in experimental science, and if chemistry or metallurgy be taught, must be supplied with apparatus and reagents in accordance with certain regulations which need not be detailed here. The main height of the laboratory must be at least fifteen feet. If this condition is not observed, no grant towards the laboratory fittings or apparatus will be made. Apparatus grants are confined to articles of a non-destructible nature, only to those of a

permanent illustrative character, which are required by the teacher.

Instruction in experimental science must not be given without sufficient apparatus to illustrate the teaching, and lists are furnished by the Department showing the minimum amount of apparatus with which it is considered necessary that a class should be provided for teaching subjects Nos. 1, 2, 6, 7, 8, 9, 10, 10p., 11p., 12, 14, 15, 19p., 22, 23, 24. No payments will be made, on examinations held in the elementary stage, in schools which are not furnished with the required amount of apparatus, or where advanced instruction is given, without sufficient apparatus to make the experiments referred to in the syllabus of each subject. The teacher is liable to be called upon by the inspector to show his ability to use this apparatus.

Students cannot be registered for lessons in more than two subjects on any one day, or more than one lesson in any one subject—except on a Saturday, when lessons in three subjects may be registered. The lessons in practical inorganic chemistry, practical organic chemistry, and practical metallurgy, must be each of at least one hour and a half's duration.

The examinations in the three stages of a subject—or in mathematics, in a group of stages—are held at the same time, a separate series of questions being given in each stage. The elementary and advanced stages are for the general students in science classes. The honors examination is of a more advanced character. In each stage there are two grades of success—first and second class. In the second or lower class of the elementary stage, the standard of attainment required is such as will justify the examiner in reporting that the instruction has been sound, and that the students have benefited by it; but the standard may be raised from year to year.

In addition to the ordinary science examinations, examinations may be made in mathematics, navigation, nautical astronomy and steam, for the benefit of seafaring men—and for them only—three times a year in all seaport towns where local committees are formed and are willing to undertake

them. These examinations are only allowed when there are at least forty candidates, and in those subjects and stages only in which there are forty candidates in the United Kingdom.

In order that the instruction of students in science may proceed methodically, a course of instruction has been prepared for both day-schools and night classes. The number of subjects which a student can take up in one year will depend upon circumstances, especially if he only attends night classes, but it is not necessary that he should take in any one year all the subjects mentioned in that year. If special grants (as provided) are claimed, however, his studies must comprise the subjects given in the course, and in the order there stated. The student is supposed to be already familiar with the elements of arithmetic and the primary conceptions of physical science, through his studies in the elementary school.

The course of instruction is as follows:

First Year.

Mathematics. (Subject 5. First stage.)

Free Drawing. (Second grade art.)

Practical Geometry. (Subject 1.)

Chemistry, inorganic. (Subject 10. First stage.) With practical work.

Physics.—Sound, light and heat (Subject 8. First stage), or magnetism and electricity, frictional and voltaic (Subject 9. First stage), or physiography (Subject 23. First stage).

Second Year.

Elementary mechanics, including the physical properties of liquids and gases. (Subject 6. First stage.)

Physics.—Sound, light and heat (Subject 8. First stage), or magnetism and electricity, frictional and voltaic (Subject 9. First stage), or physiography (Subject 23. Second stage).

Mathematics. (Second stage, and, if possible, Fourth stage. Subject 5.)

Practical Geometry (plane and solid). (Subject 1.)

Chemistry, inorganic. (Subject 10. Second stage). With practical work.

Animal physiology (if possible). (Subject 14. First stage).

Instruction in the subjects of the second year must be kept distinct from that in those of the first year. The student should also, if possible, during the first and second years, work at mechanical drawing, as provided for in the third year.

Special application should be made in case any slight modifications in the course are desired, and they will be considered on their merits.

Third Year.

The work of this year must depend so much on the student's aptitude, and the progress he has made in the preceding course, that it is impossible to lay down the subjects for this course with any definiteness. It is essential that, before continuing his course, or commencing new subjects, he should have a sound knowledge of the first stage of mathematics, elementary mechanics, physics and chemistry; that he should have such a knowledge of practical geometry and mechanical drawing as to be able to draw and read simple plans, elevations and sections with readiness, and that he should have sufficient facility in free-hand drawing to make clear and neat explanatory diagrams.

When these subjects have been mastered, the student should, while continuing his studies in mathematics, take up the first stage of animal physiology, if he has not already done so. He will then be in a position to specialize his studies, with advantage, in one of the following groups, according to his requirements, taking up, for instance:

(1) Physics and chemistry and metallurgy.

(2) Theoretical and applied mechanics, steam and machine construction, and drawing.

(3) Theoretical and applied mechanics, and building construction and drawing.

(4) Biology.

(5) Physiography, geology, mineralogy and mining.

The student may also, with advantage, continue his free-hand drawing and practical geometry.

This course has been arranged to lay the foundation of a thorough and systematic scientific training; and while certain subjects have necessarily been omitted, yet it does not follow, on this account, that they are considered unimportant.

Thus systematic botany will be found of very great use as a preliminary to the study of natural science, and as such it may be taught in elementary schools before this course is commenced, but otherwise it cannot be considered a step in a systematic course till the student takes it up as a portion of biology in his third year.

In reference to the privileges allowed to teachers, it may be stated that arrangements are made to enable a certain number of science-teachers to attend courses of instruction in science in the Normal School at South Kensington, in the months of June, July, August and September; also, a limited number of teachers, and of students in science classes, who intend to become science-teachers, are admitted free to the sessional courses of instruction in the Normal School of Science. Science-teachers are sometimes sent abroad, and travel in the service of the Department; certain special grants, railway fares, etc., are always allowed in all these cases.

Facilities are given to science-teachers to bring their students to the Museum to examine the collections.

The Normal School of Science at South Kensington is supported by the state, and is intended to supply systematic instruction in the various branches of physical science to students of all classes. While it is primarily intended for the instruction of teachers and of students of the industrial classes, selected by competition in the examinations of the Department of Science and Art, other students are admitted, so far as there may be accommodation for them, on the payment of fees fixed at a scale sufficiently high to prevent undue competition with institutions which do not receive state aid.

The instruction is arranged in such a manner as to give a thorough training in the general principles of science, fol-

lowed by advanced instruction in one or more special branches. A "Certificate of Associateship" is granted in certain divisions or lines of study, to those who go through any one of those in the prescribed order and pass the necessary examinations. The Royal School of Mines is affiliated to the Normal School, and students entering for the "Associateship" of the School of Mines, obtain their general scientific training in the Normal School of Science. Students who are not candidates for the associateship are permitted to take up the course of instruction in one or more special branches of science, and on passing the examination they receive certificates to that effect.

The associateship of the Normal School of Science is given in one or more of the following divisions:

(I)—Mechanics,
(II)—Physics,
(III)—Chemistry,
(IV)—Biology,
(V)—Geology,
(VI)—Agriculture,

and the associateship of the Royal School of Mines in:

(VII)—Metallurgy,
(VIII)—Mining.

The session is divided into two terms, the first beginning about the 4th of October and ending about the middle of February, while the second begins with the middle of February and ends about the middle of June.

The course of instruction which lasts for three years, is the same for all the divisions for the first year, after which it is specialized in accordance with the following scheme:

First Year.

All Divisions.

First Term.	*Second Term.*
Chemistry. (Part I.)	Physics. (Part I.)
	Elements of Astronomy.

Mathematics and free-hand drawing throughout each term.

Second Year.

First Term.	*Second Term.*
A.—Mechanics and mechanical drawing. (Part 1.)	Elementary geology and mineralogy.

B.—Elementary biology.

A.—For students who take associateship in Divisions I, II, III, VII or VIII.

B.—For those who take the associateship in Divisions IV, V, VI.

Instruction in mathematics so far as may be necessary, and the geometrical drawing throughout both terms.

Third Year.

I.—Mechanics

First Term.	*Second Term.*
Mechanics. (Part 2.)	Mechanics. (Part 3.)
Mathematics.	Mathematics.
Machine drawing.	Machine drawing.

II.—Physics.

Physics. (Part 2.)	Physics. (Part 3.)

III.—Chemistry.

Chemistry. (Part 2.)	Chemistry. (Part 3.)

IV.—Biology.

A.—Zoölogy. (Part 2.)	Zoölogy. (Part 2.)
B.—Botany. (Part 3.)	Botany. (Part 3.)

V.—Geology.

Geology. (Part 2.)	Geology. (Part 3.)

VI.—Agriculture.

Mechanics. (Part 1.)	Agricultural Chemistry.
Principles of Agriculture.	

VII.—Metallurgy.

Metallurgy. (Part 1.)	Metallurgy. (Part 2.)
Assaying.	Assaying.

VIII.—Mining.

First Term.	*Second Term.*
Mining.	Mining until lectures are completed.
Metallurgy.	Surveying, plan-drawing.

Three courses of evening lectures for workingmen are given during the session, in mining, astronomy and botany, the charge for admission to each course being sixpence.

[*To be continued.*]

NOTES FROM THE PARIS EXHIBITION.

Thomson's Electric Welding.—The following table gives some data regarding the power used in a number of welds and some deductions made therefrom by the writer, which may be of interest. The welds were made with wrought-iron bars; the energy was that delivered to the primary coil of the transformer; the potential was measured at the weld, and the current was calculated from the energy in the primary and the potential, allowing about 90 per cent. efficiency of the transformer.

Diameter of wrought-iron bar in inches, ...	2	2	2	1	1	¾	¾	½	½
Kilowatts in the primary, .	61·6	52·8	31·2	13	12·4	7·8	7·5	4·1	3·5
Time in seconds, ...	50	58	144	43	44	33	35	18	21
Units of heat consumed, . .	2.900	2,900	4,300	530	520	250	250	70	70
Potential at the weld in volts, ...	2.06	1·98	1·74	1·51	1·74	1·46	1·52	1·16	1·12
Current through the weld in ampères, ...	27,000	24,000	16,000	7,750	6,400	4,800	4.500	3,200	2,800

It need hardly be added that the exhibit of the Thomson welding machinery in operation, attracted probably more attention among both technical persons and the general public than any other electrical exhibit. This process represented one of the very few recent developments in electricity, of an important character in an entirely new direction.

The Bernados process of welding by the electric arc was also exhibited in operation, but it was not a success. It burns the metal, is slow, and presents very few advantages, if any, over the usual blacksmith's process. They used accumulators of 75 volts, and a current of 200 ampères. Its only commercial application at present is for welding nickel tubes on to wrought-iron ones for use in glass-blowing.

CARL HERING.

APPENDIX

TO REPORT OF SUB-COMMITTEE NO. 1,554: COMPRISING THE RECORD OF THE TESTS OF THE BATES SPINDLE, MADE BY MR. SAMUEL WEBBER.

PHILADELPHIA, March 16, 1890.

Messrs. Leclere, Fowler, Cheney, LeVan, Lees, Bilgram, Hall and Wiegand, Committee FRANKLIN INSTITUTE.

GENTLEMEN: I have carefully attended to the duty to which you have assigned me, to test the "Bates spindle" and beg leave to submit the following report: I must first premise that the spindles are too new to be fairly tested having run only about three months, while my experience has taught me that it takes at least six months to wear a spindle, as it usually leaves the shop, to its proper bearings. In proof of this I would refer you to the tests of a Bridesburg frame of Excelsior spindles at the Stark Mills in Manchester, N. H., in 1875, as follows:

The frame of 204 spindles then about three months old, the spindle weighing about eight and one-half ounces, at 4,785 revolutions per minute with a two-inch ring, required in August 7·38 foot-pounds per spindle, or at the rate of seventy-four and one-half spindles per horse-power.

The same frame repeated in November at 4,930 revolutions per minute took 6·54 foot-pounds per spindle, or eighty-four spindles per horse-power. The record of these tests will be found on pp. 70 and 71 of the *Manual of Power*, published by me in 1879, as well as other notes showing the difference due to the tension of the bands.

In the first frame tested of the Bates spindle, at Cal-

laghan's mills, at Angora, on Thursday, March 13, 1890, this tightness of fit was very evident, as several of the spindles heated sufficiently in their bearings to warm the bolster rail perceptibly, while the Whitin spindle, which had been running some three years, ran perfectly cool, both on No. 30 yarn. I will, however, report the test, as follows, with two frames of 204 spindles each:

	Bates Sp.	*Whitin Sp.*
Revolutions of front roll, counted, ...	100	100
Revolutions of spindles, calculated, ...	8,360	8,160
Average power in foot-pounds per spindle, . .	8·11	5·50
Average number spindles per horse-power, .	67·4	100
Average horse-power per frame, ...	3·144	2·219

The tests were made with both full and empty bobbins and averaged, but the total difference between full and empty bobins was only 129·5 foot-pounds for the frame of Bates spindles, while it was 180 foot-pounds with the frame of Whitin spindles, showing steadier motion for the former. The test of the Whitin spindle almost precisely duplicated similar tests at the mills at Manchaug, Mass., in September, 1887, at nearly the same velocity on nearly the same number of yarn, and in both cases the frames were in the best running order. On Monday, March 17th, a similar set of tests was made at the Gloucester Gingham Mills, Gloucester, N. J., the comparison being made between the Bates spindle and the Excelsior spindle, both built by the Bridesburg Manufacturing Company. Here, as before, the Bates spindle had been running only about three months, while the Excelsior had been running since July, 1881.

These frames were both running on No. 26 yarn, and the tests show as follows:

	Bates Sp.	*Excelsior.*
Revolutions of front roll, counted, ...	102	107
Revolutions of spindle, calculated, ...	8,039	8,430
Foot-pounds per spindle, bobbins ½ full, . .	7·35	6·89
Spindles per horse-power, bobbins ½ full, . .	75	80
Horse-power per frame, bobbins ½ full, . . .	2·727	2·554
Rolls disconnected, H. P, for rolls only, . .	·462	·491
Rolls disconnected, spindles and cylinder, .	2·264	2·064
Rolls disconnected, cylinder only, ...	·462	·462
Rolls disconnected, spindles only, ...	1·802	1·70
Spindles per horse-power, spindles only, . . .	113	120

I have no tests of the Excelsior spindle on the same number of yarn and at the same speed, for comparison, but so far as I can compare them I see no great variation from those I have previously made.

Referring to what I have previously said, I see no reason to doubt that, after three or four months' operation, the Bates spindle will run with as little power as the Excelsior, and perhaps with the Whitin, which is so far the lightest spindle I have ever tested.

One or two slight mechanical changes, which Mr. Bates has in mind—such as reducing superfluous bearing surfaces, etc.—will, I think, accomplish this end without detracting from the simplicity and accessibility of this spindle, which I consider its great merits.

Respectfully submitted,

SAMUEL WEBBER.

P. S.—I find, in looking over the above, that I have omitted another very important point, viz: that the pulleys on both frames with the Bates spindle were so small (being only seven and eight inches diameter, respectively), that a tighter belt was required to drive the frames up to speed than was necessary for the frame with the Whitin and Excelsior spindles (both of which had ten-inch pulleys), and this very difference would easily make five per cent. addition to the power consumed. S. WEBBER.

NOTES ON THE STRENGTH OF GEAR TEETH.

CHARLESTOWN, N. H., April 9, 1890.

ED. JOURNAL FRANKLIN INSTITUTE:

Dear Sir: I had occasion, recently, to make some calculations as to the size of some gears required to transmit 600 horse-power at a velocity of gear surface of about 2,000 feet per minute, and in so doing referred to a paper contributed by Mr. John H. Cooper, now of the Southwark Foundry and Machine Company, to the JOURNAL OF THE FRANKLIN INSTITUTE, in July, 1879.

I was at first struck with the great discrepancy in the

results obtained from the different formulæ quoted by Mr. Cooper, and which I will not take up space by repeating; but after careful study of the mass of data which he has condensed with great labor, I began to see daylight and to get a clear view of what I was in search of. To begin with, the great mass of the English rules are old, and are evidently calculated on the supposition that the whole strain must be resisted by one corner of one tooth. The rules of Haswell, and Jones and Laughlin are calculated for a fair bearing of the face of the tooth, and the latest rules of Nystrom, which give just double the power of that of Jones and Laughlin, are based on the full contact of two teeth, which may be relied on in gears of over thirty-six teeth, as the necessary intersection of the two circumferences will cover an arc of about 20°.

To settle the matter in my own mind, I went back to Boulton and Watt's statement, quoted by Mr. Cooper as follows:

"A bar of cast iron one inch square and twelve inches long, bears 600 pounds before it breaks; one inch long will bear 7,200 pounds, and $\frac{1}{15}$ of this 480 pounds, which is the load that should be put on a wheel."

Mr. Cooper says: "We can, therefore, rely upon Boulton and Watt's data—*i.e.*, 7,200 pounds breaks a bar of cast iron one inch square by one inch long; $\frac{7200}{3} = 2{,}400$ pounds, the elastic limit, which if exceeded would end in rupture, and $\frac{2400}{5} = 480 =$ the safe load."

Now, these results are based on the strength of English iron. American iron is stronger, not only as shown in Mr. Cooper's data, but in the following tests, which I quote from results published in the *American Machinist*, October 3, 1889, by Mr. Thomas B. West, from tests made by Rogers, Meacham and Shields, of Cincinnati, and which I have reduced to the same basis of one inch square:

Mr. Cooper's Data.	*Mr. West's Data.*
pounds.	*pounds.*
7,200	11,536
7,590	5,040
6,012	9,180

Mr. Cooper's Data. pounds.	*Mr. West's Data.* pounds.
7,416	6,720
6,720	7,278
8,000	7,824
6,000	8,754
11,046	7,470
6,207	7,974
7 969	8,478
	9,684
10) 74,166	11) 89,944
7,416·6 = average.	8,177 = average.

I, therefore, think it safe to assume 7,500 pounds, instead of 7,200, as the breaking strain, and $\frac{1}{15}$ of that, or 500 pounds, instead of 480, as the safe load. Being a decimal, it is easier to calculate. If American iron will stand 8,000 pounds, the factor will be 16 to 1. This Nystrom assumes, and formulates accordingly.

Now, if we take 500 as this coefficient, and apply it to the old rule, $\frac{f\,t^2}{l}$ = we have $500\,\frac{f\,t^2}{l}$ as the safe load.

Apply this to a tooth two inches thick. By Prof. Willis' rule of pitch = 2·2 t, and face = 2·5 P, we have pitch 4·348 inches, and face 10·87 inches. If the length of tooth to pitch line be $\frac{4}{10}$ P, it will be 1·74 inches, and if whole length be $\frac{7}{10}$ P, it will be 3·04 inches.

Then $S = 500\,\frac{f\,t^2}{l}$ gives 10,870 pounds safe load at pitch line, and $\frac{f\,t^2}{l}$ gives 7,135 pounds safe load at tip. The average would be 9,814 pounds. If we discard the t^2 and the l, and say instead $a = 500\,f\,t$, we get 10,870 pounds, a little over the average, but compensated by the fact that the strain is never wholly on the tip of one tooth long. Now, we make $F = 5·50\;T$, and "$F\;T$" will be $= 5·50\;t^2$. A horse-power is 550 pounds lifted one foot in a second, or r.

Then $\frac{500 \times 5·50\;T^2}{550} = (5\;v\;t^2) = 1$ horse-power, which is nearly the same as Haswell's formula of 5·45 $v\;t^2$, but a little stronger.

GEAR TABLE HP. = $\overset{\cdot 11}{5\,vt^2}$ PER FRACTIONS OF AN INCH. FACE = PITCH × 2½″.

Pitch.	Thickness of Tooth.	Velocity in Feet per Minute. 20	30	40	50	60	70	80	90	100	200	300	400	500	600	700	800	900	1,000	1,100
		HP	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.
¼	·114	·0217	·0324	·0434	·054	·0651	·0756	·0868	·0972	·108	·217	·324	·434	·54	·651	·756	·868	·972	1·085	1·193
⅜	·170	·0482	·0723	·0964	·1205	·1446	·1687	·1928	·2169	·241	·482	·723	·964	1·205	1·446	1·687	1·928	2·17	2·41	2·651
½	·227	·0858	·1287	·1716	·2145	·2574	·3 0	·3432	·3861	·429	·858	1·287	1·716	2·145	2·574	3·	3·432	3·86	4·29	4·72
⅝	·284	·1343	·1863	·2686	·3105	·4029	·4347	·5372	·559	·621	1·343	1·863	2·686	3·105	4·03	4·347	5·372	5·59	6·21	6·83
¾	·341	·193	·2895	·396	·4285	·579	·6755	·772	·8485	·965	1·93	2·895	3·96	4·825	5·79	6·755	7·72	8·485	9·65	10·61
⅞	·398	·264	·3954	·527	·659	·791	·9226	1·054	1·186	1·318	2·636	3·954	5·27	6·59	7·90	9·205	10·54	11·86	13·18	14·50

Pitch.	Thickness of Tooth.	Velocity in Feet per Minute. 1,200	1,300	1,400	1,500	1,600	1,700	1,800	1,900	2,000	2,100	2,200	2,300	2,400	2,500	2,600	2,700	2,800	2,900	3,000
		HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.
¼	·114	1·301	1·41	1·52	1·63	1·745	1·854	1·96	2·07	2·17	2·28	2·38	2·49	2·60	2·71	2·82	2·92	3·03	3·14	3·25
⅜	·170	2·89	3·13	3·37	3·61	3·85	4·09	4·33	4·57	4·82	5·05	5·29	5·53	5·77	6·01	6·25	6·59	6·83	7·07	7·32
½	·227	5·15	5·58	6·	6·43	6·86	7·29	7·72	8·14	8·58	9·44	9·87	10·29	10·725	11·15	11·58	12·01	12·44	12·87	13·30
⅝	·284	7·45	8·07	8·69	9·31	9·93	10·55	11·17	11·79	13·43	14·05	14·67	15·29	15·91	16·53	17·15	17·77	18·39	19·	19·64
¾	·341	11·58	12·54	13·5	14·465	15·43	16·39	17·36	18·32	19·30	20·26	21·23	22·19	23·16	24·12	25·09	26·05	27·	28·	28·95
⅞	·398	15·82	17·14	18·46	19·78	21·10	22·41	23·73	25·03	26·36	27·68	29·	30·3	31·63	32·95	34·27	35·58	36·9	38·22	39·54

TABLE No. 2.—*Safe stress in ft. lbs. (on Pitch line) from Mr. Christie's* ($F \times P \times 3{,}700$) *altered to Ratio of* ($F \times P^2 \times 3\,700$). *Calculated for P^2 only. Multiply by ratio of F to P.* 2, 2·5, or 3 *to* 1.

Pitch.	Thickness.	Breaking Strain.		Factor of Safety 4 to 1 for Quiescent Loads, or Hand-Gears, with Careful Usage.		Factor 6 to 1 for Hand-Gears with Rough Usage.		Factor 8 to 1 for Steam-Power Steadily Applied.		Factor 10 to 1 for Steam-Power Liable to Sudden Reversion.	
		Iron.	Steel.	Iron.	Steel.	Iron.	Steel.	Iron.	Steel.	Iron.	Steel.
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
¼"	·114	231	344	58	86	39	57	29	43	23	34
⅜	·170	520	773	130	193	87	129	65	96	52	77
½	·227	925	1,375	231	344	154	229	116	172	92	137
⅝	·284	1,445	2,035	361	509	221	339	180	254	144	203
¾	·341	2,081	3 093	520	773	347	515	260	385	201	309
⅞	·398	2,833	4,211	708	1,053	472	702	354	526	283	421
1	·454	3,700	5,500	925	1,375	617	917	472	687	370	550
1¼	·568	5,781	8,580	1,445	2,145	963	1,430	722	1,072	578	858
1½	·682	8,325	12,375	2,081	3,093	1,387	2,063	1,040	1,546	832	1,237
1¾	·795	11,331	16,830	2,833	4,207	1,888	2,605	1,416	2,103	1,133	1,683
2	·909	14,800	22,000	3,700	5,500	2,467	3,667	1,850	2,750	1,480	2,200
2¼	1·023	18,731	27,844	4,683	6,961	3,122	4,660	2,341	3,480	1,873	2,784
2½	1·136	23,125	34,375	5,781	8,580	3,854	5,729	2,890	4,290	2,312	3,437
2¾	1·25	27,981	41,594	6,995	10,398	4,663	6,932	3,497	5,199	2,798	4,159
3	1·363	33,300	49,500	8,325	12,375	5,550	8,250	4,162	6,187	3,330	4,950
3¼	1·477	39,081	58,280	9,770	14,570	6,513	9,713	4,885	7,285	3,908	5,828
3½	1·591	45,325	67,375	11,331	16,830	7,554	11,229	5,665	8,415	4,532	6,737
3¾	1·704	52,031	77,343	13,008	19,336	8,672	12,890	6,504	9,668	5,203	7,734
4	1·818	59,200	88,000	14,800	22,000	9,867	14,667	7,400	11,000	5,920	8,800
4¼	1·932	66,830	99,330	16,708	24,842	11,138	16,555	8,354	12,420	6,683	9,933
4½	2·045	74,925	111,375	18,731	27,844	12,487	18,562	9,365	13,922	7,492	11,137
4¾	2·158	83,480	124,080	20,870	31,020	13,913	20,680	10,435	15,510	8,348	12,409
5	2·272	92,500	137,500	23,125	34,375	15,416	22,916	11,562	17,197	9,250	13,750
5¼	2·386	101,980	151,580	25,495	37,895	16,996	25,263	12,747	18,947	10,198	15,158
5½	2·500	111,925	166,375	27,981	41,594	18,654	27,730	13,990	20,791	11,192	16,637
5¾	2·613	122,331	181,830	30,583	45,457	20,388	30,305	15,291	22,728	12,233	18,183
6	2·727	133,200	198,000	33,300	49,500	22,200	33,000	16,650	24,750	13,320	19,800

It would give, applied to Mr. Cooper's second table, 149·226 horse-power for one tooth, as against Jones' and Laughlin's, 147·27 horse-power, and 298·45 horse-power for two teeth, as against Nystrom's 295·59 horse-power. The only difference being that, instead of following Mr. Cooper exactly, I have unthinkingly switched off onto the rule of my old friend, Prof. Willis, and given t as ·4545 P, instead of ·46 P, as Mr. Cooper has it. It is sufficient to show me that the formulæ of both Jones and Laughlin and Nystrom are reliable, ***provided***, which is the great point, that the gears are rigidly supported in their bearings, and kept square up to the work on their full faces, and the shafts fully up to Mr. Francis' rule of

$$\text{Diam.} = \sqrt[3]{\frac{\text{H.P.} \times 100}{\text{Rev. per min.}}}$$

I also send you a gear table, which I have calculated on the above basis, which may be convenient to some of your readers; acknowledging my obligations to Mr. Cooper for the valuable collection of *data* which he has got together.

Yours very truly,

SAMUEL WEBBER.

By the suggestion of Mr. Cooper, I have also prepared a table, showing the breaking and safe strains, on teeth of different sizes, taking as a basis Mr. Christie's formula of $(P \times F \times 3{,}700)$.

This I change to $(P^2 \times \text{Ratio of } F \times 3{,}700)$, which is the same thing really, for convenience in determining the relative values of P and F, and in order that the rule may be applicable to teeth of different width of face, and it only differs in this case from Mr. Cooper's result from Mr. Christie's formula as 10,405 pounds to 10,395 pounds.

P is here taken at the *pitch line*, but, by careful examination, I think it may be assumed that the thickness of a well-formed tooth at the base will be about 1·4 times that at the pitch line, giving a square of 1·96 to 1, while the leverage from the extreme tip would be as 1·75 to 1 at pitch line.

Jo *(Webber.)*

…on. Cast Steel will give one-half more power. Cast Iron Gears of over …where one tip clears as another takes hold.

Pitch.	…ft.	1,600 ft.	1,700 ft.	1,800 ft.	1,900 ft.	2,000 ft.	2,100 ft.	2,200 ft.	2,300 ft.	2,400 ft.
	…P.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.	HP.
1″	…86	27·58	29·31	31·03	32·75	34·48	36·20	37·93	39·65	41·37
1¼	…32	43·	45·70	48·38	51·07	53·77	56·46	59·15	61·83	64·52
1½	…12	62·	65·87	69·75	73·62	77·50	81·37	85·25	89·12	93·
1¾	…97	84·24	89·50	94·77	100·	105·3	110·56	115·83	121·09	126·36
2	…47	111·44	118·4	125·37	132·33	139·30	146·26	153·23	160·19	167·16
2¼	…72	139·44	148·15	156·87	165·58	174·3	183·	191·73	200·44	209·16
2½	…25	172·	182·75	193·5	204·25	215·	225·75	236·5	247·25	258·
2¾	…3	208·32	221·34	234·36	247·4	260·5	273·52	286·54	299·56	312·58
3	…2	247·7	263·16	278·64	294·12	309·6	325·08	340·56	356·04	371·52
3¼	…6	290·8	308·9	327·1	345·3	363·5	381·7	399·8	418·	436·2
3½	…4	337·5	358·6	379·6	400·7	421·8	442·9	464·	485·1	506·2
3¾		387·2	411·4	435·6	459·8	484·	508·2	532·4	556·6	580·8
4	…1	440·6	468·2	495·7	523·3	550·8	578·3	605·9	633·4	661·
4¼	…6	497·7	528·8	559·9	590·	621·1	653·2	684·3	715·4	746·5
4½	…7	557·6	592·4	627·3	662·1	697·	731·8	766·7	801·5	836·4
4¾″	…1	620·9	659·7	698·5	737·3	776·2	815·	853·8	892·6	931·4
5		688·	731·	774·	817·	860·	903·	946·	989·	1032·
5¼	…6	759·	806·4	853·9	901·3	949·	996·3	1043·7	1091·2	1138·6
5½		833·2	885·3	937·4	989·5	1042·	1094·	1146·	1198·	1250·
5¾	…5	910·4	967·3	1024·2	1081·1	1138·	1195·	1252·	1309·	1366·
6		992·	1054·	1116·	1178·	1240·	1302·	1364·	1426·	1488

This practically eliminates *l*, and the fact that the tips of the teeth are so rounded off that the pressure seldom comes on the extreme point of one tooth, and when it does, is diagonal to the line of least resistance, instead of vertical, enables me to do so entirely, and, as my table, made out in this manner, gives for a safe strain for a tooth of three-inch pitch, such as Mr. Cooper uses for his basis, with a factor of 8 to 1, a load of 4,162 pounds $\times$ 2·5, or 10,405 pounds, while Mr. Nystrom, with the same factor, gives, by formula 20, 10,350 pounds, and by formula 21, 12·242 pounds, I think it is safe. S. W.

NOTE ON FRESH-WATER WELLS OF THE ATLANTIC BEACH.

Anything which will throw light upon the character of the drinking water which is supplied to the hundreds of thousands of sojourners by the New Jersey sea-coast, must necessarily have interest to the public, and especially to parents, for nowhere else does a sick child recover so rapidly as at the seashore, if other conditions are favorable.

The practice, during the last five years, has tended toward sinking artesian wells near most of the larger summer hotels. The supply of water by this means was so abundant and excellent that the New Jersey State Geological Survey, under the late able and much lamented Prof. George Cook, determined the water-bearing planes, and published the depths at which these might be expected in bore holes along the sea-coast from Sandy Hook to Cape May. The wells which have since been driven have amply proved the soundness of the data.

But in numbers of cases it is not possible to resort to deep boring, and in these cases the supply is by surface wells sunk a short distance below the sand. Of course, these wells are permissible only in cases where, for a considerable distance around them, the population is sparse and there are few cesspools or collections of decaying matter, and in some cases these conditions obtain sufficiently to justify the

use of surface wells, but sooner or later these must be abandoned and recourse must be had to artesian borings, which, fortunately, need not be very deep, to furnish an ample supply for all needs.

In order to give to the layman an idea of the condition of the strata and their relation to the water supply of the coast, it may be said that the famous marl beds of New Jersey, with the clays and sands which divide and intermingle with them, form impervious beds through which water cannot percolate. They cross the State from about Long Branch to the old town of Salem, near Fort Delaware, running approximately southwest, and inclining or dipping in a direction perpendicular to this (or southeast), at a gentle angle of about twenty feet to the mile. These are the water-bearing floors which supply the greater part of the artesian wells sunk along the coast between Long Branch and Cape May, though there are other and higher planes along which more or less good water is constantly flowing downward to and entering the sea at a greater or less distance from the coast. The permanence and purity of a supply will depend upon the extent of country which pours its rainfall upon the upper edges of these marl strata or the overlying clay beds. The outcrop of these strata is not parallel with the coast line, but runs inland to the southwest; it is, therefore, obvious that the farther one goes to the south from the intersection of these strata with the ocean border, the deeper must the well be bored in order to find water. One of the upper marl beds touches the sea line at Asbury Park, and the next higher marl at about Branchport. To reach the water flowing along the upper planes of the first deposit at the Beach House, Sea Girt, for instance, one would be obliged to sink about 160 feet; and to reach the probably larger supply of the marl next below at the same point, a depth of 240 feet would be required. But before coming upon these well-known horizons of good water, it is extremely probable that others would be found, representing higher clays, as was the case at Berkeley, on the Barnegat Beach.

But to return to the surface wells. There is at the

Beach House a well sunk by Commodore Stockton, when the middle house was his seaside home. This well is familiar to all who have visited this place. It is a prominent object on the lower porch of the hotel, and furnishes all the water consumed for drinking and cooking purposes. The depth of the bottom of the well is 20 feet 5 inches from the surface, and its average depth of water is three feet. One of its peculiarities which astonishes those unfamiliar with the behavior of streams of water at points near their confluence with another body of water of varying depth, is that the level of the perfectly sweet and fresh water rises and falls with the tide in the ocean 150 feet to the east of it. This is not at all remarkable when one reflects that the same ocean tide causes the fresh water of the Delaware and Schuylkill to rise, and their surface currents to retreat towards the mouths of those streams, though eighty-odd miles from the ocean.

The water which fills this well represents the drainage of a few square miles around Sea Girt, and is simply the rain water filtered through the sand and gravel of the coast belt, and collected on the surface of some local intercalated bed of clay. Were the region thus drained as thickly populated as a few other parts of the coastal belt the water would probably be unfit for drinking purposes; but it happens that the settlement of this area is sparse and its contamination from putrifying substances small. The writer has been in the habit of drinking the water of the Stockton well for eleven summers, and of seeing it continually used by invalids and children without ever having heard of any deleterious effect produced by it.

For the purpose of investigating whether or not it were potable as well as to learn something of the nature of the water from similar wells on the New Jersey coast, having first filled and rinsed a perfectly clean five-gallon demijohn twelve times with water, he collected a fair average sample. Subjoined are the results of this examination:

Water slightly alkaline:	*In a Million Parts.*	*Grains per Gallon.*
Free ammonia,	0·033	—
Albuminoid ammonia,	0·090	—
Chlorine,	—	4·2
Total solids in solution,	—	29·0

As to the two forms of ammonia this corresponds closely with an analysis by Wanklyn, of the water of the River Lea, supplied by the East London Water Company to the citizens of London. The percentage of albuminoid ammonia is only 0·01 higher than that found by the same distinguished analyst in the water of Loch Katrine, which supplies the people of Glasgow. While not extraordinary on account of its purity it is well within the limits beyond which chemical analysis indicates danger.

The same is the case with the chlorine and total solid constituents. They present no ground for suspicion of dangerous contamination, and indicate what a subsequent examination of the drainage system proved, viz: that the latter was in good condition, and carried all sewage in closed pipes to an inlet connecting with the Manasquan River about a mile away from the house. This is but one instance, and it may be an exceptional one, on the coast of New Jersey, where a surface well is still utilizable. The time will come when such supply can no longer be resorted to, but in this case it has not yet arrived.

PERSIFOR FRAZER.

THE ELECTROLYTIC METHOD AS APPLIED TO PALLADIUM.

BY EDGAR F. SMITH AND HARRY F. KELLER.

[*Read at the Stated Meeting of the Chemical Section, March 18, 1890.*]

Our knowledge bearing upon the behavior of this metal towards the current is limited and rather indefinite. In 1868, Wöhler published, in the *Annalen*, **143**, 375, an article entitled, "Ueber das Verhalten einiger Metalle im elektrischen Strom," from which the following facts are taken: Palladium, as the positive pole of a battery, consisting of two Bunsen cells, was immersed in water acidulated with sulphuric acid, when the metal immediately became coated with a deposit having a bright steel-like color. This deposit is doubtless palladium dioxide, as it liberates chlorine when treated with hydrochloric acid, and carbon dioxide when warmed with oxalic acid. At the same time, black, amorphous metal separated upon the negative pole. Its quantity was slight. In the second edition of *Classen's Quantitative Electrolysis*, p. 72 (American edition), it is stated that a feeble current will deposit palladium in a beautiful metallic state from an acid solution. One Bunsen cell is given as sufficient for this purpose. A more energetic current produces a spongy deposit. Ludwig Schucht has communicated* that from an aqueous solution of palladious nitrate, acidulated with a few drops of nitric acid, the current precipitated upon the negative pole a bronze-colored deposit, which, as it grew more dense, became darker, and finally black in color. At the positive pole there was a simultaneous deposition of oxide, showing a reddish color. In alkaline palladic solutions the precipitation of metal was much retarded; the deposition of oxide was also observed.

Our first experience in the electrolysis of palladium salts was acquired from the double cyanide in an excess of potas-

* Berg- und Hüttenmännische Zeitung **38**, 121; also, Zeit. für anal. Chem., **22**, 240.

sium cyanide. In such solution a current, generating one cc. oxyhydrogen gas per minute, failed to cause metallic deposition until after the expiration of thirty-six hours; in other words, not until the excess of potassium cyanide had been completely converted into alkaline carbonates. Then the deposit was black in color, but the precipitation was not at all complete. No deposition of oxide was noticed upon the positive pole. The conduct of the metal in cyanide solution led to the trial of certain separations, the results of which will be given in a later communication. The action of the current (feeble) was also tried upon a solution of palladious chloride, in the presence of a large excess of potassium sulphocyanide. In this case the deposition of metal was exceedingly rapid. Spongy spots were noticeable. The deposit was black in color. The experiment was made with this solution in the hope that possibly a separation of copper from palladium might be found; but, as these metals separate with equal rapidity from their sulphocyanides, the results are valueless for this purpose.

The next attempt was made with palladammonium chloride, $Pd(NH_3)_2Cl_2$, in just sufficient ammonium hydroxide to retain it in solution. The total dilution of the solution was 125 cc.; the acting current gave 0·9 cc. OH gas per minute. The poles were distant from each other about two inches. Just as soon as the circuit was completed, a yellowish-brown coating appeared upon the spiral of the positive pole; while upon the dish, in connection with the negative pole, a deposit of metal closely resembling the platinum itself in color made its appearance. After acting through the night the current was interrupted, the metal deposit carefully dried and weighed. The precipitation was incomplete. It was, however, discovered that the deposition at the positive pole, which gradually increased in mass and assumed a black color, had entirely disappeared. In all instances where the ammonium hydroxide was in decided excess, the precipitation of oxide on the positive pole was not observed. This behavior is similar to that of nickel when its ammoniacal solutions are electrolyzed. In subsequent experiments the course was somewhat modified. From solutions such as

just described, the palladium thrown out upon the platinum dish was extremely slow in dissolving, even in fuming nitric acid, so that it was deemed expedient to first coat the platinum dishes employed in the electrolysis with a layer of silver, varying in weight from 0·1 to 0·3 gram. This was done in the experiments recorded below, and was found to be decidedly advantageous. The layer of silver seemed to hasten the deposition of the palladium.

EXPERIMENT I.

A quantity of palladammonium chloride (= 0·2228 gram Pd) was dissolved in ammonium hydroxide; to this solution were added 20 to 30 cc. of the same reagent (sp. gr. 0·935) and 75 cc. water. The current allowed to act upon this ammoniacal liquid gave 0·9 cc. oxyhydrogen gas per minute. The decomposition continued through the night. At no time was there any oxide deposition upon the anode. The palladium gradually assumed a bright metallic appearance. After drying, the deposit showed about the same appearance as is ordinarily observed with this metal in sheet form. The washing was limited to hot water, and when the deposit was perfectly dry, the dish containing it was covered with a watch glass and exposed to a temperature ranging from 110° to 115° C. This was done to expel any hydrogen that might possibly have been retained by the palladium.

Weight of silvered dish + Pd = 61·9575 grams.
" " " — Pd = 68·7350
0·2225 Pd.

EXPERIMENT II.

In every respect similar to Experiment I, gave

Weight of silvered dish + Pd = 71·9540 grams.
" " " — Pd = 71·7315
0·2225 Pd.

The filtrates from these deposits were warmed for eight hours with ammonium sulphide without showing any formation whatever of palladium sulphide.

In several experiments, with conditions unlike those just described, and where consequently an incomplete precipita-

tion of metal occurred, the digestion with ammonium sulphide produced in every instance, in a very short time, a reddish-brown flocculent sulphide, carrying with it quite a considerable quantity of free sulphur.

In a second series of two experiments, in each of which there was the same amount of palladium as in the previous trials, the quantity of ammonium hydroxide in excess was made 30 cc., while the current (giving 0·8 cc. oxyhydrogen gas per minute) was allowed to act for sixteen hours. The results were quite concordant:

EXPERIMENT III.

Weight of silvered dish + Pd = 72·1055
" " " — Pd = 71·8825

Weight Pd = 0·2230 gram.

EXPERIMENT IV.

Weight of silvered dish + Pd = 62·0512
" " " — Pd = 61·8280

Weight Pd = 0·2232

It may be remarked that in filling the silvered platinum dishes a rather large surface of silver was allowed to remain above the electrolyzed liquid, so that by merely adding water it was possible to ascertain when the palladium was fully precipitated. When the deposition was not finished the new silver surface soon showed streaks of metal.

A third series of two experiments, in which the added amount of palladium was double that recorded in the preceding examples, the same conditions were observed as before, with the exception that as the current was only giving 0·70 cc. oxyhydrogen gas per minute, the time of precipitation was extended to eighteen hours. The results were as follows:

EXPERIMENT V.

Weight of silvered dish + Pd = 72·3555
" " " — Pd = 71·9100

Weight Pd = 0·4455

EXPERIMENT VI.

Weight of silvered dish + Pd = 62·2600
" " " — Pd = 61·8138

Weight Pd = 0·4462

Curiously enough, upon warming the liquid poured off from the palladium in Experiment V, with ammonium sulphide there appeared a very slight sulphide precipitate after some hours. The liquid from Experiment VI showed no trace of unprecipitated metal.

The deposits in the experiments just recorded were bright, metallic and very dense. In none was there the slightest tendency to sponginess. To show the accuracy of the method, the results may be tabulated as follows:

Experiment.	*Found Pd.*	*Calculated Pd.*
I,	0·2225	0·2228
II,	0·2225	0·2228
III,	0·2230	0·2228
IV,	0·2232	0·2228
V,	0·4455	0·4456
VI,	0·4462	0·4456

If the percentage differences be calculated, it will be found that they are quite within the limit of error occurring in almost any ordinary gravimetric determination.

The behavior of ammoniacal palladium solutions, when exposed to the action of the electric current, will be further studied as time permits, and, if possible, the attempt will be made to re-determine the atomic weight of the metal by this method in a somewhat modified form.

University of Pennsylvania,
Philadelphia, February 12, 1890.

NOTES AND COMMENTS.

CHEMISTRY.

Indian Industrial Products—*Jour. Soc. Chem. Industry*, **9**, 670.—The following information respecting dyes and tanning materials and lac are extracted from a memorandum on Indian inland trade compiled in the Revenue and Agricultural Departments of the Government of India, and which has recently been issued from the Government central printing office at Simla.

Dyes and *tans* comprise indigo, myrabolans, cutch, turmeric, aniline dyes, and "others." The first is by far the most important, and stands at 323 lakhs of rupees* in a total trade in dyes and tans valued at 442 lakhs of rupees.

* A lakh of rupees = 100,000 rupees.

Bengal, the Northwestern Provinces, and Oudh and Madras, are the principal sources of commercial indigo, and their combined exports during the year amounted to 289½ lakhs of rupees, viz: Bengal 187½, Northwestern Provinces and Oudh seventy-three and one-half, and Madras twenty-eight and one-half lakhs of rupees. It is also grown rather extensively in the Punjab, but chiefly for local consumption. Elsewhere its cultivation is not unknown, but it is unimportant.

Indigo manufacture in Bengal has a long history, marked by many vicissitudes of fortune; but notwithstanding some serious checks, and, in later years, the competition of aniline and other dyes, it continues to hold its place as one of the great industries of the province. The total area under indigo in Bengal is estimated to be 588,000 acres, and the manufacture is in the hands of European capitalists. The season was fairly prosperous, and the exports amounted to 90,616 maunds.

In the Northwestern Provinces and Oudh, where canal irrigation is used, the average area under indigo is about 337,000 acres. Unlike Bengal, the manufacture is, except in the eastern districts, in the hands of natives.

The crop of 1888–89 was not a good one, owing to heavy rains, and exports fell from 43,000 maunds in 1887–88 to 40,000 maunds.

Madras indigo is commercially less valuable than that of Northern India. The area under cultivation amounts to between 400,000 and 500,000 acres. The exports were 23,866 maunds, against 26,000 maunds in the preceding year.

Myrabolans, the fruit of a species of *Terminalia*, are exported principally from the forests of the Central Provinces and Bombay to Bombay town. During the year the exports of the Central Provinces amounted to 5·31 lakhs of rupees in value, and of the Bombay Presidency to 3·34 lakhs of rupees.

The Indian trade in cutch is insignificant compared with that of Burma, and the total value was under eight lakhs of rupees.

Turmeric, the roasted root-stock of *Curcuma longa*, is a condiment as well as a dye, and is extensively used by the natives and Anglo-Indians for this purpose. The principal localities of production are Bengal, Madras, and the Northwestern Provinces and Oudh. The total export amounted to fifteen and one-half lakhs of rupees.

The growing popularity of aniline dyes is illustrated by the general distribution of the imports by sea among the internal trade blocks.

Lac.—Of the three commercial products of the insects, *Coccus lacca*, which cause the secretion of this resin, viz: stick-lac, shell-lac and lac-dye, the trade in the two former only is separately recorded. Lac-dye, which is obtained from the washing of stick-lac, and is a coloring matter derived from the female insect, imbedded in the resinous secretion, has, since the introduction of chemical dyes, almost disappeared as an article of export. Stick-lac is the crude product incrusting the twigs on which it is formed, but has, it is to be feared, been confounded in the returns in some instances with the manufactured article. Shell-lac is the pure resin extracted from stick-lac, which is pounded and exposed to heat for the purpose. *Coccus lacca* has a wide distribution and affects various trees, but is collected principally from

two or three species of fig. The jungles of the Central Provinces are the chief sources of supply. In Assam the insect is regularly cultivated on two varieties of fig. The inland trade this year is valued at 101 lakhs of rupees.

H. T.

GAMBIER AT SINGAPORE—Annual report of Singapore Botanical Gardens; through *Jour. Soc. Chem. Industry*, **9**, 670.—Gambier is one of the most important products of Singapore, but, although it still maintains its high price, there are many complaints from England that the imported article is heavily adulterated with water. In order to trace the origin of this excess, samples taken from the field fresh from the boiling-shed were sent to Mr. Evans, of Bristol, whose analysis, as compared with a sample of block-gambier received by him in the ordinary course of trade, was as follows:

	Gambier from the Field. *per cent.*	*Trade Gambier.* *per cent.*
Tannin,	11·48	14·68
Organic matter,	30·11	42·26
Water,	53·39	31·89
Ash,	4·46	6·34
Loss,	0·56	4·48
	100·00	99·65

The result shows that there is actually less water in the trade article than in the gambier taken directly from the coolies' hands, and negatives the suggestion that the town *Towkay* adulterates the gambier, after receiving it in Singapore, with water to make it heavier. The other suggestion that the gambier has deteriorated of late years from insufficient inspiration, owing to less fuel being used in boiling, seems more probable. In earlier years, when there was no attempt made to protect the forests, the destruction of firing was very large, and fuel could be had in large quantities. Now the results of this wasteful destruction are being felt, and the gambier is insufficiently boiled and dried.

Persons interested in the trade recently conceived the idea of forming a company in Singapore to cultivate gambier on a large scale, but this has fallen through, and there is an idea that this product may be cultivated more profitably, that is with European labor, in other of our colonies. Consequently, most botanical establishments have applied to the Singapore gardens for seeds or young plants, and a large quantity of seed was carefully collected, dried, and distributed widely, but, as far as has yet been heard, the experiments with it have failed entirely. It seems now certain that gambier seed has a very short duration of life (the Chinese say only twenty-four hours)—that is, it must be sown as soon as ripe. Thus, all attempts to send seed to distant colonies must prove futile. Unfortunately, too, young plants are very bad travellers, and though many have been sent out to different establishments, few appear to survive the voyage. More plants, in as healthy a condition as possible, are now to be sent out to various colonies where gambier is likely to thrive. H. T.

BOOK NOTICES.

ELECTRICAL RULES, TABLES, TESTS AND FORMULÆ. By Andrew Jamieson, C.E., F.R.S.E. New York: The Industrial Publication Company.

This little book contains a very brief compilation of the formulæ of the absolute units; practical, electrical, mechanical, heat and light units; electro-chemical equivalents; electrolysis, heat and energy of combustion; practical methods of electrical measurements; electric conductors, copper, etc.; insulators, gutta-percha, etc.; submarine cables; aërial land lines; electric lighting and transmission of power, as is indicated in its announcement.

Unfortunately, however, the compilation has been entirely too brief to be of much general value. It appears to be a cheap and much abbreviated edition of Monroe and Jamieson's excellent *Pocket Companion.* Owing to its cheapness it may be a useful book to have around on account of some of its data and the table concerning submarine cables, which has a description of various constructions, methods of laying and testing, data of many of the present submarine cables. The data respecting overland telegraph lines and aërial cables, tables of resistance, weight, etc., of copper; Willoughby Smith's gutta-percha, etc., will be useful.

The part of the book devoted to testing and electrical measurements might as well have been omitted, as it will not be of much use to anyone desiring aid in testing; but few tests are described and some of these are faulty.

A serious defect in the book, in addition to its very poor typography, cuts, etc., is that there is no index and therefore no easy way of finding things.

It is unfortunate that in compiling this book, the lines were so sharply drawn, for with a very slight increase of outlay and a little *more* clipping of general information, it might have been made far more valuable. H. S. H.

ALTERNATING CURRENTS OF ELECTRICITY. By T. H. Blakesley. New York: D. Van Nostrand Company.

The second edition of this very interesting series of papers has been added to the electrical literature of the day.

Mr. Blakesley originated the application of the geometric treatment of simple periodic motion to alternating currents, and his papers on the subject appeared originally in the *Electrician*, the *Transactions of the Physical Society* and in the *Philosophical Magazine*, and this collection, to which many additions have been made, is very acceptable as it facilitates a careful study of the subject.

The subject has certainly required considerable thought as the treatment is a very thorough one, notwithstanding difficulties. The chapter on the condenser transformer, not before published, is particularly interesting on account of the conclusions drawn. This geometric treatment of alternating currents is not of much practical value, however, as the calculations are based on mere assumptions; but it is a very interesting study, and this is one of the books which all who are interested in the modern developments of electrical science should read. H. S. H.

PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR JULY, 1890.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, July 31, 1890.

TEMPERATURE.

The mean temperature of 59 stations for July, 1890, was 70°·8, which is about 1°·5 below the normal, and 1°·4 below the corresponding month of 1889.

The mean of the daily maximum and minimum temperatures 82°·3 and 59°·1 give an average daily range of 23°·2, and a monthly mean of 70°·7.

Highest monthly mean, 75°·1 at Rimersburg.

Lowest monthly mean, 64°·8 at Dyberry.

Highest temperature recorded during the month, 101° on the 8th, at Carlisle and York.

Lowest temperature, 33° on the 6th at Huntingdon.

Greatest local monthly range, 33°·0 at Huntingdon.

Least local monthly range, 14°·9 at Rimersburg.

Greatest daily range, 56° at Huntingdon on 7th.

Least daily range, 3° at Selins Grove on 2d, and Ligonier on 9th.

From January 1, 1890, to July 31, 1890, the excess in temperature at Philadelphia was 666°, at Erie 382° and at Pittsburgh 682°.

BAROMETER.

The mean pressure for the month, 30·03, is about ·07 above the normal. At the U. S. Signal Service Stations, the highest observed was 30·31 at Erie on the 21st, and the lowest 29·716 at Philadelphia on the 3d.

PRECIPITATION.

The average rainfall 3·52 inches for the month, is a deficiency of over a half inch. The distribution was unequally divided, and in some sections growing crops suffered from drouth.

The largest monthly totals in inches were Lynnport, 6·40; Girardville 6·36 and West Chester, 6·27.

The least were Phillipsburg, 0·74 and Erie, 0·76.

WIND AND WEATHER.

The prevailing direction of wind was from the west. The month was characterized by extremes of heat and cold. Several stations reported light frosts on the 21st. The weather was favorable for the harvesting of grass and grain, and unusually large crops of hay were secured.

Average number: Rainy days, 8; clear days, 13; fair days, 11; cloudy days, 7.

Correction.—From January 1, 1890, to June 30, 1890, the excess in temperature at Philadelphia was 714°, at Erie 421° and at Pittsburgh 685°.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Blue Knob, 1st, 4th, 8th, 13th, 15th, 17th, 25th, 27th, 29th; Hollidaysburg, 4th, 15th, 17th, 26th; Wysox, 1st, 2d, 17th, 31st; Le Roy, 2d, 15th, 17th; Quakertown, 17th, 18th; Johnstown, 4th, 25th, 29th; Emporium, 8th, 15th, 17th, 25th, 29th; State College, 2d, 9th, 15th, 17th, 29th; Phillipsburg, 8th, 15th, 17th; West Chester, 3d, 4th, 15th, 17th; Coatesville, 15th, 17th; Kennett Square, 4th, 15th, 17th; Rimersburg, 1st, 2d, 25th, 29th; Lock Haven, 3d, 4th, 9th, 17th, 24th, 27th, 30th; Catawissa, 8th, 15th, 17th, 26th; Meadville, 1st, 2d, 4th, 8th, 17th, 24th, 25th, 28th, 29th, 31st; Carlisle, 2d, 3d; Harrisburg, 3d, 17th; Swarthmore, 3d, 15th, 17th; Erie, 8th, 24th, 25th, 28th, 31st; Uniontown, 1st, 15th; Huntingdon, 2d, 16th, 17th, 27th; Petersburg, 15th, 17th; Indiana, 15th, 25th; Myerstown, 15th, 17th, 28th; Annville, 3d, 15th, 17th; Coopersburg, 17th; Drifton, 15th, 17th; Wilkes-Barre, 15th; Nisbet, 4th, 9th, 15th, 16th, 17th, 29th; Lewistown, 2d, 15th, 17th; Pottstown, 17th; Philadelphia, 3d, 4th, 13th, 17th; Girardville, 2d, 3d, 9th, 17th; Selins Grove, 2d, 3d, 15th, 17th, 29th; Somerset, 15th, 25th; Eagles Mere, 8th, 15th, 17th; Wellsboro, 2d, 8th, 15th, 17th, 25th, 29th; Lewisburg, 2d, 3d, 15th, 17th; Columbus, 8th, 15th, 24th, 31st; Canonsburg, 4th, 15th; Dyberry, 3d, 15th, 17th, 26th; South Eaton, 3d, 8th, 15th, 17th; York, 2d, 3d, 15th, 16th, 18th, 26th.

Hail.—Johnstown, 25th; Catawissa, 17th; Swarthmore, 17th; Uniontown, 15th; Philadelphia, 17th; Girardville, 17th; Selins Grove, 8th, 15th.

Frost.—Blue Knob, 6th, 10th, 21st; Quakertown, 21st, 22d; Emporium, 21st; Phillipsburg, 13th; Grampian Hills, 20th, 21st; Catawissa, 21st; Somerset, 6th, 10th, 20th, 21st; Wellsboro, 10th, 21st, 22d; Lewisburg, 21st; Columbus, 21st; Dyberry, 21st; Honesdale, 21st.

Aurora.—Quakertown, 7th, 9th, 18th.

Coronæ.—Blue Knob, 29th; Annville, 27th..

Solar Halos.—Le Roy, 23d, 27th, 28th; Meadville, 19th, 28th; Wilkes-Barre, 28th; Eagles Mere, 27th, 28th; Dyberry, 28th.

Lunar Halos.—Annville, 27th; Selins Grove, 19th.

Meteors.—Quakertown, 7th; Greenville, 19th; Canonsburg, 21st.

Parhelias.—Le Roy, 17th; Annville, 27th.

Zodiacal Lights.—Charlesville, 4th, 5th, 7th, 9th, 10th.

ER SERVICE FOR JULY, 1890.

Cou	Precipitation: Total Inches.	Precipitation: Number of Days Rainfall.	Number of Days: Clear.	Number of Days: Fair.	Number of Days: Cloudy.	Wind, Prevailing Direction: 7 A. M.	Wind, Prevailing Direction: 2 P. M.	Wind, Prevailing Direction: 9 P. M.	Observers.
Adams,[1]	2·78	9	16	6	9	S	S	S	Prof. E. S. Breidenbaugh.
Allegheny	2·22	15	11	15	5	SW	SW	SW	Oscar D. Stewart, Sgt. Sig. Corps.
Bedford,	1·53	6	16	9	6	SW	SW	SW	Miss E. A. G. Apple.
Blair,[2]	3·22	...	...	...	...	...	...	...	Dr. Charles B. Dudley.
Blair,	1·60	4	16	11	4	SW	NW	NW	A. H. Boyle.
Blair,	2·37	4	20	7	4	W	W	S	Prof. J. A. Stewart.
Blair,	1·85	5	9	11	11	W	W	W	Miss Cora J. Wilson.
Bradford,	3·62	9	12	13	6	SE	SE	SE	Charles Beecher.
Bradford,	2·51	8	11	9	11	SW	SW	SW	Geo. W. T. Warburton.
Bucks,	4·41	9	16	8	7	N	W	W	J. C. Hilsman.
Bucks,	5·50	15	12	9	10	SW	SW	SW	J. L. Heacock.
Cambria,	1·87	7	10	17	4	S	S	S	E. C. Lorentz.
Cameron,	4·87	9	12	9	6	W	W	W	T B. Lloyd.
Carbon,[1]	5·79	9	15	10	6	NW	NW	NW	John J. Boyd.
Centre,	2·44	8	11	11	9	N	W	W	Prof. Wm. Frear.
Centre,	10·74	4	10	12	2	SW	SW	SW	Geo. H. Dunkle.
Chester,	6·27	14	18	6	7	SW	S	SE	Jesse C. Green, D.D.S.
Chester,	3·77	11	16	6	9	S	S	S	W. T. Gordon.
Chester,[1]	5·17	11	9	12	10	S	S	S	Benj. P. Kirk.
Chester,	...	...	...	...	...	...	...	...	Prof. Wm. F. Wickersham.
Clarion,	...	...	13	14	4	W	W	W	Rev. W. W. Deatrick, A.M.
Clarion,	...	...	...	...	...	...	...	...	C. M. Thomas, B.S.
Clearfiel	3·37	9	10	13	8	W	SW	W	Nathan Moore.
Clinton,	2·85	10	19	4	8	W	W	W	Prof. John A. Robb.
Columbi	3·58	8	...	...	...	...	...	...	Robert M. Graham.
Crawford	2·76	7	12	15	4	S	S	S	J. & B. H. Metcalf.
Cumberl	1·91	5	9	13	5	W	S	SW	J. E. Pague.
Dauphin	2·80	10	11	10	10	W	W	W	Frank Ridgway, Sgt. Sig. Corps.
Delawar	3·67	8	2	16	13	NW	SW	SW	Prof. Susan J. Cunningham.
Erie,[1]	·76	8	12	12	7	S	S	S	Peter Wood, Sgt. Sig. Corps.
Fayette,	5·65	7	19	11	1	SW	SW	SW	Wm. Hunt.
Forrest,	...	...	...	...	...	...	...	...	R. L. Haslet.
Franklin	...	...	...	...	...	...	...	...	Miss Mary A. Ricker.
Fulton,	3·12	8	15	10	6	S	W	W	Thomas F. Sloan.
Greene,	2·50	7	...	...	...	...	...	...	Capt. W. C. Kimber.
Hunting	·56	5	17	6	8	W	W	W	Prof. W. J. Swigart.
Hunting	·04	7	18	10	3	W	S	W	J. E. Rooney.
Indiana,	2·05	6	13	13	5	SW	W	NW	Prof. S C. Schmucker.
Lackaw	...	...	...	...	...	...	...	...	C. A. Hinsdell.
Lancast	...	...	...	...	...	...	...	...	C. N. Heller.
Lawrenc	·55	6	20	6	5	S	S	S	Wm. T. Butz.
Lebanon	·36	10	10	11	10	W	W	W	Wm. H. Kline.
Lebanon	...	...	6	17	8	W	SW	SW	Geo. W. Bowman, A.M., Ph.D.
Lehigh,	5·53	11	14	8	9	SE	SE	SE	M. H. Boye.
Lehigh,[1]	5·40	...	16	6	9	...	...	...	John C. Wuchter.
Luzerne,	5·92	9	...	...	...	...	...	...	H. D. Miller, M.D.
Luzerne,	·78	11	20	2	9	NE	...	SE	A. W Betterly.
Lycomin	·80	9	...	..	...	W	...	SE	John S. Gibson, P. M.
Mercer,	·52	7	10	14	7	SW	...	N	Prof S. H. Miller.
Mifflin,	·47	9	16	7	8	NW	W	W	Culbertson & Lantz.
Montgo	·45	8	17	8	6	NW	SW	W	Charles Moore, D.D.S.
Northa	...	...	...	...	...	...	...	...	Lerch & Rice.
Philadel	·03	11	8	13	10	N	N	N	Luther M. Dey, Sgt. Sig. Corps.
Potter,	...	...	...	...	...	...	...	...	C. L. Peck.
Schuylk	·36	11	21	3	7	W	W	W	E. C Wagner.
Snyder,	·58	9	4	16	11	SE	SE	SW	J. M. Boyer,
Somerse	·36	6	10	15	6	NW	NW	NW	W. M. Schrock.
Sullivan,	·24	9	12	9	10	SW	SW	SW	E. S. Chase.
Tioga,	·65	12	8	14	9	N	NW	NW	H. D. Deming.
Union,[1]	·79	8	9	18	4	SW	SW	SW	F. O. Whitman.
Warren,	·95	11	12	14	5	SW	SW	SW	Wm. Loveland.
Washin	·93	8	15	11	5	SW	W	E	A. L. Runion, M.D.
Wayne,	·45	10	12	10	9	NW	W	NW	Theodore Day.
Wayne,	·73	10	...	...	...	...	...	...	John Torrey.
Westmo	·47	7	19	10	2	...	...	...	J. T. Ambrose.
Wyomi	·72	8	11	16	4	S	...	NW	Benj. M. Hall.
York,[1]	·77	7	17	9	5	NW	NW	NW	Mrs. L. H. Grenewald.

[1] Ob

T. F. TOWNSEND, *Sergeant Signal Corps, Assistant.*

	Lansdale.	Forks of Nesham'y	Germantown.	Point Pleasant.	Bethlehem.	Canonsburg.	Carlisle.	McConnellsburg.	Waynesburg.	Lewisburg.	Mauch Chunk.	Nisbet.	Charlesville.	Lynnport.	Tionesta.	Gettysburg.	Lewistown.	Greensburg.	Tipton.	Coudersport.	Coopersburg.	Westtown.	Meadville.	Ligonier.	Scranton.
1						.85			.30				.25						.80					.25	
2	.67	.70	.50	1.28		.02	.22			.40	1.79	.20				.26	.77				1.70		.58		
3	.48	.79	.20	.50			.05			.02	.15					.08	.32				.40				
4			.35					.30	.30		.01		.01			.10	.05		.70				.56	.40	
5			.05			.58															.01				
6																									
7																									
8																							.35		
9										.16		.50					.04						.44		
10																									
11																									
12													*												
13	.11	.09	.30	.05												.06					.08				
14							.03																		
15	.35	.01	.14			1.04		.19		1.80	.80	.90							.12		.08			.10	
16			.10			.76	.25	.27	.50			.40					.42								
17	.10	.32	.77	.80				.46	.20	.81	.98	.80					.02		.11		.44				
18			.08					.41								.11	.02								
19																									
20																									
21																									
22							*																		
23						.08	*		.25																
24		.02	.05			.45	*	.85	.60	.41	.83	.30	.94			1.03	.20		.12		.24		.10	1.27	
25	.51		.70				*	.47	.35	.01	.90	.30	.09			.40	.20				.97		.37	.01	
26		1.54	1.02	2.47			1.36	.17		.18	.27	.20	.12			.55	.42				1.01			.37	
27																									
28		.01	.02													.17	.01				.31			.07	
29	.08	.93	.85	.28		.15					.06	.20	.12			.02					.29				
30																									
31																							.36		
	30	4.41	5.13	5.38	. .	3.93	1.91	3.12	2.50	3.79	5.79	3.80	1.53	6.40	. .	2.78	2.47	. .	1.85	. .	5.53	. .	2.76	2.47	. .

T. F. T.

WEATHER FORECASTS.

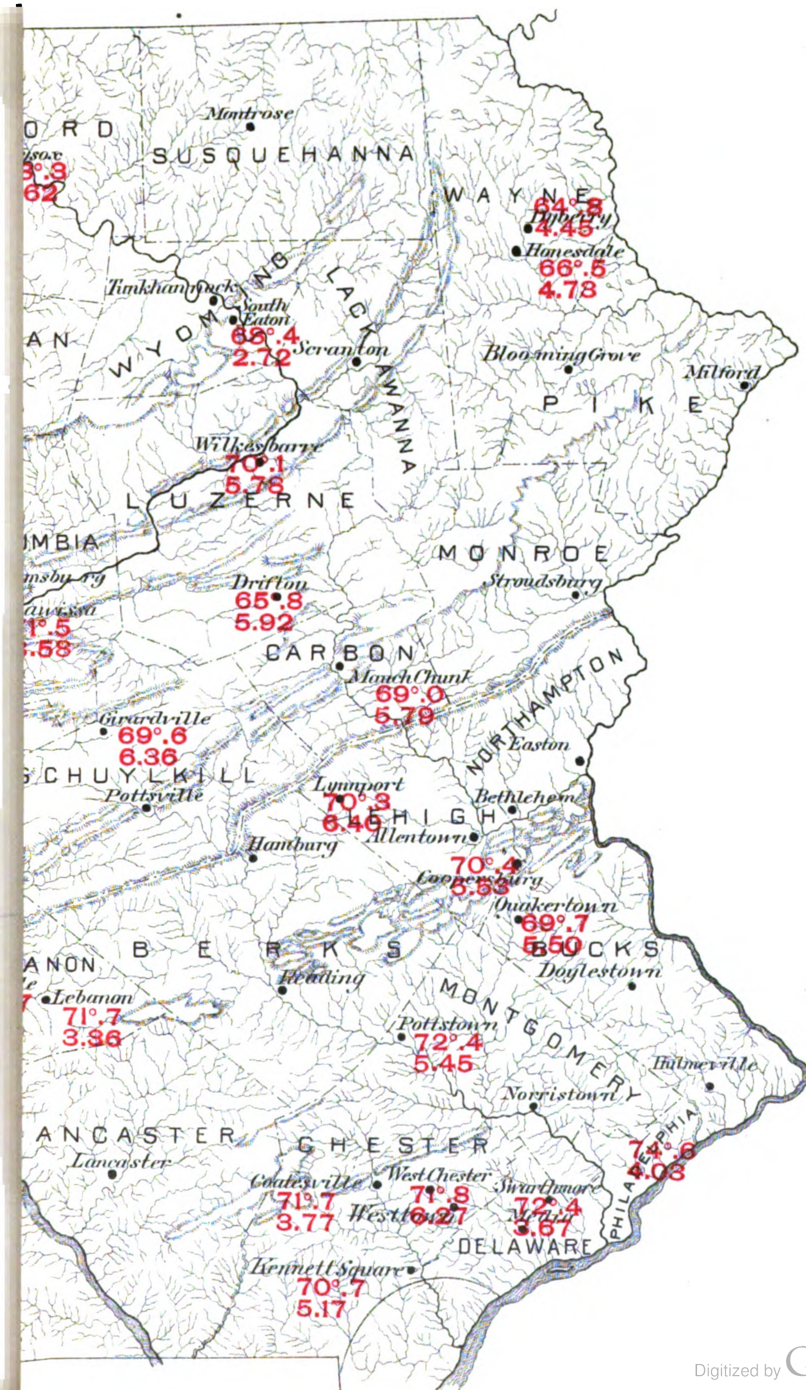
Percentage of local verifications of weather and temperature signals as reported by displaymen for July, 1890:

Weather, 86 per cent.
Temperature, 91 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
C. W. Burkhart,	Shoemakersville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
Capt. A. Goldsmith,	Quakertown.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
New Era,	Lancaster.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
J. E. Forsythe,	Butler.
Steward M. Dreher,	Stroudsburg.
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock,

Displayman.	*Station.*
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. M. Wildman,	Langhorne.
G. W. Klee,	Chambersburg.
A. Simon's Sons,	Lock Haven.
Raftsman's Journal,	Clearfield.
R. C. Schmidt & Co.,	Belle Vernon.
Chas. B. Lutz,	Bloomsburg.
E. C. Lorentz,	Johnstown.
W. M. James,	Ashland.
Miller & Allison,	Punxsutawney.
Dr. A. L. Runion,	Canonsburg.
E. J. Sellers,	Kutztown.
C. A. Hinsdell,	Scranton.
H. M. Kaisinger,	Hartsville.
E. Jennet,	Franklin.
Foulk & Co.,	Milford.
William Lawton,	Wilmington, Del.
Wister Heberton & Co.,	Germantown.
Charles M. Mullen,	Bedford.
E. W. Merrill,	North East.
A. Simon's Sons,	Lock Haven.
Frank Ridgway,	Harrisburg.
G. W. Yost,	Collegeville.
A. C. Tryon,	Spartansburg.


SUSQUEHANNA
Montrose
WAYNE
64°.8
4.45
Honesdale
66°.5
4.78
WYOMING
Tunkhannock
South Eaton
2.72
LACKAWANNA
Scranton
Blooming Grove
PIKE
Milford
Wilkesbarre
70°.1
5.76
LUZERNE
MONROE
Stroudsburg
Drifton
65°.8
5.92
CARBON
Mauch Chunk
69°.0
5.79
NORTHAMPTON
Easton
Girardville
69°.6
6.36
SCHUYLKILL
Pottsville
Lynnport
70°.3
6.40
LEHIGH
Bethlehem
Allentown
Hamburg
70°.4
5.63
Quakertown
69°.7
BERKS
BUCKS
Doylestown
Reading
Lebanon
71°.7
3.36
MONTGOMERY
Pottstown
72°.4
5.45
Norristown
ANCASTER
Lancaster
CHESTER
Coatesville
71°.7
3.77
West Chester
71°.8
Swarthmore
72°.4
3.67
DELAWARE
PHILADELPHIA
74°.6
4.03
Kennett Square
70°.7
5.17

Hall of the Institute.

JULY, 1890.

Notice is hereby given that the Committee on Science and the Arts of the FRANKLIN INSTITUTE has recommended the award of

The Elliott Cresson Medal

TO

STOCKTON BATES, EDWIN F. SHAW AND

GEO. M. VON CULIN,

for their Improvements in

"SUPPORTS FOR SPINNING SPINDLES."

Any objection to the above recommendation should be communicated within three months of the date of this notice to the Secretary of the FRANKLIN INSTITUTE, Philadelphia.

WILLIAM H. WAHL, Secretary.

Entered at the Post Office at Philadelphia in accordance with Section 199 of the Postal Laws and Regulations.

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DEVOTED TO

Science and the Mechanic Arts.

EDITED BY

Third Series. OCTOBER, 1890. VOL. C.—No. 4.

CONTENTS.

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JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXX. OCTOBER, 1890. NO. 4

ON SCHOOLS: WITH PARTICULAR REFERENCE TO TRADES SCHOOLS.

BY JOSEPH M. WILSON, A.M., C.E.
President of the FRANKLIN INSTITUTE.

[*Concluded from vol. cxxx, p. 220.*]

REGULATIONS SPECIAL TO ART.

Aid is given towards instruction in the branches of art named below, which for convenience of references are divided into stages, and there are three grades of examination, the first grade being for elementary schools only; the second grade, of a more advanced character, and the third grade of a still higher standard.

The different stages are as follows:

(1) Linear drawing by aid of instruments.

(2) Free-hand outline drawing of rigid forms from flat examples.

(3) Free-hand outline drawing from the "round."

(4) Shading from flat examples.

(5) Shading from the "round" or solid forms.

(6) Drawing the human figure and animal forms from flat examples.

(7) Drawing flowers, foliage and objects of natural history from flat examples.

(8) Drawing the human figure, or animal forms, from the "round" or nature.

(9) Anatomical studies.

(10) Drawing flowers, foliage, landscape details and objects of natural history from nature.

(11) Painting ornament from flat examples.

(12) Painting ornament from the cast, etc.

(13) Painting from flat examples, flowers, still-life, etc.

(14) Painting direct from nature.

(15) Painting (from nature) groups of still life, flowers, etc., as compositions of color.

(16) Painting the human figure or animals in monochrome from casts.

(17) Painting the human figure or animals in color.

(18) Modelling ornament.

(19) Modelling the human figure or animals.

(20) Modelling fruits, flowers, foliage and objects of natural history from nature.

(21) Time sketches in clay of the human figure, or animals, from nature.

(22) Elementary design.

(23) Applied designs technical or miscellaneous studies.

Grants are made towards the cost of fittings, the purchase of apparatus, examples and works of reference, in accordance with certain conditions.

In schools of art, both day and night classes must be held, and there must be a night class for artisans, meeting under the instruction of the master for two hours, at least three times a week, during forty weeks in the year.

There are rules governing the formation of branch classes; qualifications of teachers; granting of certificates, and regulations as to students, which need not be considered here. There are also special rules as to examinations, regulations as to works sent to South Kensington for examination, etc.

Grants are made for travelling, to masters and students, to enable a limited number of those connected with schools of art to see the works not only at home but also in special cases in foreign towns, schools and galleries, to make sketches, to study, or to do special work for the Department.

A national training-school is established in London, for the purpose of training art masters and mistresses for the United Kingdom, and for the instruction of students in drawing, designing, and modelling, to be applied to architecture and manufactures. Free admission to the courses of instruction is granted to students in training, national scholars and free students. Admission is also granted to the general public on payment of fees. The school is open for study every week-day, excepting Saturday, from 9 A.M. to 4 P.M. with an interval of half an hour for lunch, and from 7 P.M. to 9 P.M. and all life classes and class lectures commence at 10 and close at 3.30. The annual session consists of two terms, each lasting five months.

Aid is extended by the department of science and art, to the advancement of drawing in the elementary schools, and to training-colleges for teachers, but the details are not pertinent to the present inquiry.

It is believed that the extracts which have been given from the directory of the Department, which have been mostly verbatim, are sufficient to enable those interested in the subject to obtain a fair idea of the work embraced by this Board of the Council on Education. Still further information can be obtained, however, from the directory itself, if desired.

THE CITY AND GUILDS OF LONDON INSTITUTE FOR THE ADVANCEMENT OF TECHNICAL EDUCATION.

This Institute owes its origin to the city livery companies of London, and it was established for the purpose of providing and encouraging education, such as will be adapted to the requirements of all classes of persons engaged, or preparing to engage, in manufacturing and other industries.

In carrying out its object, it arranges to subsidize existing educational establishments which, in the opinion of the Council of the Institute, are already providing sound technical instruction, and which, if not supplied with external aid, would possibly languish or fail in their purpose.

This Institute also encourages, in the principal industrial centres of Great Britain, the formation of evening classes, in which workmen and foremen, engaged in their business during the day, can receive special instruction in the principles of science, in their application to the processes with the practical details of which they are already familiar.

It aims at establishing and maintaining in London model technical schools, to serve as examples for other schools that may be founded and supported by local efforts in provincial towns; and it has erected and supports a central institution to serve as a great polytechnic school corresponding in its purpose to those of Germany, Switzerland and Italy, and to the École Centrale of Paris, obviating the necessity of students going abroad for technical education. The City and Guilds of London Institute fills up the interval between the school and the workshop, and assists in the professional instruction of all classes of persons engaged in industrial pursuits—of artisans, apprentices, foremen, managers of works, manufacturers and technical teachers; not in any way proposing to interfere with existing social institutions, such as apprenticeship, or other relations between the master and workman, but only to provide for a long-felt and pressing want, in supplementing the training of the workshop by instruction in the general principles underlying the profession of the student, giving him what it is impossible for him to obtain in the best organized shop, and enabling him the better to profit by the training he does get, when he enters the shop.

In order to establish technical classes in London and in provincial manufacturing towns, the Institute granted, for a period of years, certain annual sums, ranging from £400 to 200, to University College, London; Kings College, London; Horological Institute; School of Art Wood-Carving; Firth College, Sheffield; University College, Sheffield; and Technical School, Manchester.

It has also given considerable sums to other Institutions, and in nearly all the large manufacturing towns it is assisting evening classes in technology, as distinguished from the government classes in science and art. The Institute attends to the inspection and examination of the work done by the students of these classes and grants certificates and prizes to those deserving them, these, as diplomas of proficiency, being of great value in enabling operatives to obtain better employment and higher remuneration. These evening classes, are the nuclei of technical colleges, principally supported by the towns in which they originate, but connected with, and affiliated to the parent Institute by means of the examinations and supervising influence which it has over them.

Studies are prosecuted and examinations held in such subjects as the following: (Programme of 1883-4.) Salt and alkali manufacture; soap manufacture; bread-making; brewing; distilling of coal tar and manufacture of spirits; sugar manufacture; fuel; manufacture of oils; colors and varnishes; oils and fats, including candle manufacture; gas manufacture; manufacture of iron and steel; of paper and porcelain, of glass; dyeing in silk and wool; bleaching, dyeing and printing of calico or linen; tanning of leather; photography; electro-metallurgy; manufacture of textile fabrics; lace manufacture; weaving and pattern designing; electrical engineering; metal plate work; plumber's work; silversmith's work; watch and clock-making; tools, wood-working and metal-working; mechanical engineering; carriage building; printing; mechanical preparation of ores; mine surveying; milling; carpentry and joinery.

The Finsbury Technical College, which was opened in 1883, was erected at a cost of £36,000 by the City and Guilds of London Institute, as a model trade-school, where artisans and others preparing for intermediate posts in industrial works could be instructed. It is a school of applied science and art, with day and evening classes, the latter providing systematic instruction for those who are engaged in the staple industries of the district, including cabinet-making; and in the applications of chemistry, mechanics and physics to special trades.

This college has made an approach to the establishment of a relationship with the principal middle-class schools of the metropolis, by the award, to selected pupils from these schools, of exhibitions, enabling them, without payment or fees, to receive in the college, scientific and technical training, fitting them for various occupations and industries, as well as for higher technical instruction.

The subjects taught comprise mathematics, pure and applied; practical mechanics, chemistry and physics; electrical technology; free-hand, model and machine drawing· workshop practice; French and German; and in the evening, additional classes are held in carpentry and joinery; metal plate work; bricklaying; drawing; painting; modelling, and design.

The South London Technical Art School, which is also under the auspices of the City and Guilds of London Institute, provides instruction for artisans engaged in various industries where aptitude in arts is essential to success. The courses provide for evening and day students, men and women, and the subjects of instruction include drawing, modelling and painting from life; wood-engraving; china-painting; enamelling and design.

The Central Institution of the City and Guilds of London Technical Institute, is located on the Exhibition Road, opposite to the South Kensington Museum and close to the Natural History Museum. It provides a high-class technical college where teachers for the provincial schools may be educated, and where students may be trained to take positions of trust in charge of great industrial works and manufactories.

The building has a frontage of about 300 feet, and is for the most part five stories in height. In the basement are the engineering work-shops and laboratory, the forge-room, dynamo-rooms, dynamo and motor-testing room, physical laboratories, the laboratory of mechanics, and the joiners' shop. The ground floor is mainly occupied by class-rooms, the entrance hall being in the centre of the building, and the great corridor extending from one end to the other. The optical laboratory and private rooms for three of the professors are also on this floor.

Over the entrance, on the first floor, is a large reading-room and library, the balance of this floor being used for physical laboratories and the offices of administration. The second floor has a large room in the centre, used as a museum for engineering, mathematical and physical models, and in the other portions are chemical laboratories, lecture-rooms, applied art studios, and a school of wood-carving, the latter not properly belonging to the school and only allowed temporary room. A large room on the third floor is used as an engineering drawing office, and other rooms for chemical laboratories, also a students' refreshment-room. At the back of the building are two large lecture-rooms, one for chemistry, and the other for physics and mechanics.

This technical Institute was opened in June, 1884, with such men at its head as Profs. Henrici, Unwin, Ayrton and Armstrong, each aided by a staff of assistants. The subjects of instruction were indicated to be chemistry, engineering, mechanics, mathematics, physics, drawing, manufacturing technology, workshop practice, modern languages and applied art, and in addition to the three complete courses specially arranged for students to enter engineering, electrical or chemical industries; those who are sufficiently advanced are admitted to any course they may select, or to do special work in the laboratories, working as many hours a week as they desire.

Short courses of lectures and laboratory demonstrations on various branches of applied science and the technology of particular industries are given during the summer by the professors and outside lecturers, especially adapted to the requirements of the technological teachers of the Institute, who have free admission to them, and also open to other persons on the payment of small fees.

Students entering the Institute for the complete course must pass an entrance or matriculation examination in elementary mathematics and mechanics, mechanical drawing, physics, chemistry and either French or German. This examination takes place at the end of September, and is open to all persons of not less than sixteen years of age. There

are several scholarships of a value running from £60 a year, together with free education, down to £30 a year, which are awarded at this time on the results of the examination, making the contest very interesting. The regular courses begin in October and continue until the end of June, with the usual Christmas and Easter vacations. The complete course is three years, the first year being the same for all students.

It seems hardly necessary to give details of the various studies and the methods of teaching, etc., as it is very similar to what is adopted in the best technical schools of the United States, and the subject is a little beyond the special object of this paper; but it may be stated that every effort is made to combine practical work with high theoretical teaching; the workshops and laboratories are well equipped, and students are taught at each step to apply their theoretical knowledge to practical problems, the result being that they are prepared for grappling successfully with the great questions which will come to them in their future career; their interest is awakened, even with dull students, to the practical value of what they learn, and at the same time, the professors have the best possible test of the reality and thoroughness of the knowledge they gain. A series of very interesting papers on this Institute will be found in *London Engineering*, vol. xlvi, 1888.

THE POLYTECHNIC YOUNG MEN'S CHRISTIAN INSTITUTE, REGENT STREET, LONDON.

This Institute originated many years ago as a philanthropic effort, and in its first form took the shape of a ragged school. After that it developed into a semi-scientific exhibition, where such things as "Pepper's Ghost," the "Automaton Chess Player," etc., were the principal attractions. Then it was purchased by Mr. Quintin Hogg, and transformed by him into a Young Men's Christian Institute, a polytechnic not only in name but in fact, with its educational and technical classes, athletic and gymnastic clubs, recreation societies, etc. It is in a very flourishing condition, thousands of young men annually pass through its various

classes, and the number of its members has increased until the capacity of the immense building is severely taxed. What Mr. Hogg has done for the young men, Mrs. Hogg has accomplished for the young women, and it is an institute for both sexes, the department for the former being at 309 Regent Street, and for the latter at 15 Langham Place. Mr. Quintin Hogg is President of both departments.

That for young men is intended for artisans, apprentices and others; the building is open every evening, Sundays and bank holidays excepted, from 5.30 until 10.30, and all between the ages of sixteen and twenty-five are eligible for membership. A subscription of three shillings per quarter, payable in advance, entitles members to the free use of the library, reading, social, chess and draughts rooms, also to the use of the splendid gymnasium, admission to the swimming-bath, concerts, entertainments, lectures, etc.; and the privilege of joining any of the classes, at greatly reduced rates.

A recreation ground of twenty-seven acres, at Merton Hall, Wimbledon, is reserved for the use of members. Many societies and clubs are formed from among the members, and are managed by their own committees.

Young men of eligible age wishing to join the Institute, enter their names in the candidates' register, at the office, at the same time paying a registration fee of one shilling, which will constitute their entrance fee when they become members. As vacancies occur, candidates are communicated with by the Secretary in the order of their registration.

The swimming-bath, said to be one of the handsomest in the kingdom, adjoins the gymnasium, and is open for members from May until October. There are swimming races held weekly, and the Institute challenge cup is swum for, monthly, during the season. A fee of three pence is charged for admission to the swimming-bath, and instruction is given every evening free.

The gymnasium is under the charge of a first-class certificated instructor, with qualified assistants, and members of the Institute have the use of the gymnasium, with

private locker, for three shillings per annum. Squad and mass exercise take place every evening, and instruction is given in single stick, fencing, dumb-bell, indian club, bar bell, horizontal bar, parallel bars, rings, trapeze, etc. Displays are frequently given by members in different parts of London.

The following societies and clubs are held in connection with the Institute: Polytechnic Sick Fund; Christian Workers' Union; Total Abstinence Society; Athletic Club, with ground at Merton Hall; Cycling Club; Polytechnic Rambles, with walking excursions into the country every Saturday afternoon; Polytechnic Harriers, one of the Premier Clubs of London; Boxing Club; Mutual Improvement Society; Polytechnic "E" Company (West London Rifles), fourth Middlesex; Volunteer Medical Staff Corps; Polytechnic Battery, No. 7, First City of London Artillery Volunteers; Polytechnic Company, First Middlesex Engineers; Polytechnic Military Band; Orchestral Society; Male Choir; Choral Society; Chess and Draughts Club; Short-hand Society; Literary Society; Polytechnic Parliament; Polytechnic German Society; French Society; Electrical Engineering Society; Engineering Society; Savings Bank; Insurance against Accidents; Polytechnic Physical Development Society.

The Institute is intended principally for apprentices and young artisans, and these constitute the mass of the members, although others are admitted. Special efforts are made in the educational department to provide the members with the opportunity of acquiring a sound theoretical and practical knowledge of their various trades, and care has been taken that the instruction should not be too difficult to be understood by the average mechanic. The classes of the educational department are open to both sexes of all ages, members and non-members, the fees being higher for the latter. During the session of 1888–1889, the number of individual students enrolled exceeded 8,846. The workshops are replete with requirements, and the photographic studio is one of the best in London. Lavatories, refreshment bar, etc., are also provided for the convenience of

students. The practical and technical classes are limited to members of the trade in question.

The classes in this department are divided under the following heads: Technical; practical trade; commercial and general; special examination preparatory; science; musical; elocution, and Saturday classes.

The technical class subjects are bread-making; brickwork and masonry; carpentry and joinery; cabinet-making; carriage building; electrical engineering; mechanical engineering; metal-plate working; typography; lithography; photography; plumbing; boot and shoemaking; watch-making; quantities and estimating; oils and fats; tools.

The practical trade classes comprise: Brass finishing; brick-cutting: cabinet-making; chasing and repoussé; carpentry and joinery; stair-case and hand-railing; electrical work; metal-turning and finishing; upholstery; tailor's cutting; plumbing; wood-carving; watch-making; etching.

The commercial and general classes include: Arithmetic; book-keeping; composition; writing; grammar; reading and spelling; French; German; short-hand; type-writing.

The special examination preparatory classes are intended for preparation for the different civil-service examinations and for medical and pharmaceutical preliminary and Latin elementary examinations.

The science classes are for: Agriculture; geology; geometry; machine construction; magnetism and electricity; mechanics, theoretical and applied; mathematics; mineralogy; physiography; botany; sound, light, heat; steam and steam engineering; animal physiology; hygiene; chemistry, inorganic and organic; building construction.

The musical and elocution classes teach the specialties in those departments, and the Saturday classes are arranged for chemistry; geometry; machine construction; French; art modelling, etc., and short-hand.

The Polytechnic School of Art Department of this Institute is at 155 Great Fitchfield Street, in connection with South Kensington, and is open for students of both sexes.

It is considered one of the largest Metropolitan schools of art and possesses a very large collection of statuary and casts, together with a fine antique gallery. It is stated that the number of successes in the examinations and of prizes obtained by students in this school places it in the front rank of Government schools of art. There is a day department, and also an evening department for artisans and others obtaining their own livelihood, and who undertake to attend the Government examinations in May. Members of the Institute obtain a reduction in fees, as also apprentices and pupil-teachers.

The school teaches free-hand and model drawing; geometry and perspective; drawing from the cast and antique; painting in monochrome, oil and water colors, designing, etc.; drawing, painting and modelling from life; drawing and painting from still life; modelling in clay and wax; wood-carving; etching on copper; ornamental design; chasing and repoussé work.

Prizes, in value from about $5 to $25 each, are offered to competitors in the school of art for best designs, drawings, modellings, etc., by such men as the Duke of Westminster, Earl of Aberdeen, Lord Kinnard and firms, such as Winsor & Newton, etc.

At the Young Women's Department of the Institute in Langham Place, those between the ages of sixteen and twenty-five are eligible for membership, and the building is open from 6.30 until 10 P.M., Sundays and bank holidays excepted, the gymnasium being open only on Tuesday and Thursday evenings. A subscription of 1*s.* 6*d.* per quarter, or five shillings per annum, payable in advance, entitles members, amongst other privileges, to the use of the reading-room and social-rooms; admission to concerts, lectures, entertainments, etc., at member's rates, and the privilege of joining any of the classes at greatly reduced fees.

The swimming-bath is reserved on Friday nights for members and their friends; admission, three pence for members and four pence for friends.

Bible classes are conducted on Monday evenings and on Sunday afternoons. In this connection we may mention

that in the Young Men's Department there is held on Sunday what is stated to be one of the largest Bible classes in the world.

The table of special classes for young women only, comprises: Ambulance, book-keeping, arithmetic, French, elocution, civil service, telegraphing, writing, violin, piano, harmonium, dress cutting and making, millinery, cookery, typewriting, etc.

The courses of instruction in plain and high-class cookery are very complete; special attention is paid to individual requirements and to giving good practical instruction in household cookery. The number of students in the practical classes is limited to twenty.

The fees in the high-class cookery, practical department, are, for non-members, five shillings, and for members, 3*s.* 6*d.*, while for the demonstration they are, non-members, two shillings; members, one shilling, and single lessons, three pence. In household cookery, the fees for the practical course are, non-members, 3*s.* 6*d.*; members, 2*s.* 6*d.*, and for the demonstration, non-members, one shilling; members, sixpence; single lectures, twopence.

The St. John ambulance, for rendering first aid to the injured and home nursing, is connected with this Institution, and a special course of lectures and demonstrations is given for ladies only, each lecture lasting one hour, a second hour being devoted to practical instruction in bandaging.

After the course is over an examination is held for those desirous of obtaining the St. John Ambulance Society's Certificate. The tickets for the course are 10*s.* 6*d.* each.

THE PEOPLE'S PALACE TECHNICAL SCHOOLS.

What the Polytechnic is doing for the neighborhood of Regent Street, the People's Palace is doing for East London. This is a large institution for the "recreation and amusement, the intellectual and material advancement, of the vast artisan population of the East End." Its form was suggested by the Palace of Delight" described in Mr. Walter Besant's novel, "All Sorts of Conditions of Men," and the nucleus of the £100,000 required for its erection, was fur-

nished by an endownment of Mr. J. F. Barber Beaumont, who died in 1841, which was largely increased by voluntary public subscriptions, including £60,000 from the Drapers Company of London.

The great central building, the "Queen's Hall," was opened by Queen Victoria in May, 1887, and active work was begun in the palace in October of that year.

The buildings are not yet entirely completed, and some of those that are in use are only temporary, but good service is made of the facilities already provided and a great work is being done.

The present permanent buildings consist of the Queen's Hall, a beautiful audience-room, capable of seating 3,500 people, and nearly 6,000 have been in it at one time; a library, now containing over 12,000 volumes, absolutely free to the public, although books cannot be taken out of it; and a four-story structure on the east of the hall, devoted to the educational department and appropriated as follows: The basement contains men's and women's cloak-rooms and lavatories, the engine-room, engineer's-room, pattern-making and moulding-room, brick-work and masonry-room and electric laboratory; on the ground floor are the administrative offices, the lecture-room, with gallery over, the mechanical drawing-room, and a class-room; the first floor comprises a building construction drawing-room, the head master's room, men teacher's room, and class-rooms; the third floor accommodates the chemical laboratories, class-rooms and a lecture-room; and in the roof is the photographic studio. In addition to these buildings, there is a swimming-bath, containing a pool 90 feet long by 60 feet wide, 6 feet deep at one end and 4 feet at the other, the water in it being entirely changed every day; and also the refreshment building and gymnasium, which are temporary for the present, until arrangements can be made for permanent structures.

The work of the Institution may be considered under three general heads: The recreative section, the educational section, and the social or institute section. The report of the Chairman of Trustees, Sir Edmund Hay Currie,

for October 1, 1888, the latest annual report at my disposal, gives some idea of the work carried on.

In the recreative section, exhibitions and shows are held. Thus there was from October 26 to 30, 1887, a poultry and pigeon show, the charge for admission being fixed at twopence. Over 36,500 persons attended; many valuable money and other prizes were given, and great interest was shown in the exhibits by the inhabitants of many quarters of the East End. Then, on November 16th of the same year, the Princess Christian visited the palace and opened a show of chrysanthemums, nearly 20,000 people attending, at the low rate of admission of twopence for adults and one penny for children.

On December 10th, the Prince of Wales opened an exhibition of the work of London apprentices, and announced the granting of an endowment by the Charity Commissioners of £2,500 a year and the gift by the Drapers Company of £40,000 for the same purpose. This exhibition remained opened until January 7, 1888, and was visited by 86,000 persons, there being nearly 30,000 present on boxing day and the day following. Prizes and souvenirs were given as awards for creditable work exhibited, and the undertaking was a great success.

Other shows and exhibitions were given from time to time with like results. On Good Friday there was a special free organ recital, attracting nearly 800 persons, and in the evening a fine rendition of the "Messiah," admission threepence, which was attended by 3,363. During Easter week, a concert was given every night, with a total attendance of 35,861. In April, a series of afternoon entertainments were given to children, for three days, with an attendance of 7,771, and afterwards, on four Saturdays, with an average attendance each day of 1,500.

In May, there was a workman's exhibition, open for six weeks, perhaps the most important exhibition of the year, over 96,000 persons visiting it.

In July, a donkey and pony show was held, for two days, attracting nearly 7,000 persons to it. Each man exhibiting for both days, received *7s. 6d.* for his time, and those

exhibiting only one day, 2*s*. 6*d*. each. The Royal Society for the Prevention of Cruelty to Animals and the Coster's Society, each contributed toward the expenses of this show.

In August and September, there was an exhibition of modern pictures, and a six weeks' autumn *fête*, which was one of the most successful undertakings made in the People's Palace. There were some 150 pictures exhibited, including many specimens of the works of Watts, Richmond, Millais, Hook, Landseer, Alma Tadema, Hallé, Faed, and many other well-known artists. During the first few days of the *fête*, a flower show was held in the centre of the Queen's Hall, and during the whole period, the exhibition buildings were partly laid out as a garden and palm-house; a platform was provided for music, and numerous side-shows and other attractions were given, everything possible being done to make the place bright and attractive for the people. The charge for admission was fixed at a penny, and 310,207 persons came during the six weeks, 27,055 attending on bank holiday alone, and nearly 70,000 during the first week. The utmost comfort and good humor prevailed among these large masses of people, and even the very poor, to whom even the charge of twopence or threepence is at times almost prohibitive, flocked in very large numbers through the turnstiles, at the low price—very poorly-dressed men, women and children, indeed, forming the bulk of the visitors.

During the whole of the year, except during the autumn *fête*, concerts were held twice a week in the Queen's Hall, and on special occasions more frequently, the average attendance at these concerts being about 2,500. Arrangements are now made to set apart Wednesday evenings during the whole session, entirely for concerts and entertainments of various kinds, students being admitted to these by payment of sixpence per quarter, in addition to the class fees. These entertainments are of high class, and are arranged especially to interest and give wholesome pleasure to the people. Concerts are also arranged for on Saturday evenings. These entertainments are open to the public, the charges for Wednesday evenings being threepence, and

for Saturdays twopence. Sometimes a profit is made, and at other times there is a deficiency which must be made up.

Sacred musical recitals are given every Sunday, at 12 noon, 4 P.M., and 8 P.M., upon the very fine organ which has been presented to the Palace, and the average attendance has been almost 1,000, nearly all men. It is believed that much good results from these concerts.

The free library and reading-room are well patronized, the report for 1888 giving an average of from 900 to 1,000 readers on week-days and 1,750 on Sundays. The rooms are open on Saturdays until 10 P. M. Numbers of ladies and gentlemen give their assistance in the library on Sunday, without which it would be impossible to carry out the work, as no paid services are employed on that day. The reading-room is opened at 7.30 each morning, for the convenience of men out of work, who desire to consult advertisement columns, etc.

The swimming-bath proved to be a success at once, as many as 1,292 being admitted in one day during its first summer, and nearly 70,000 having availed themselves of its privileges in four and a half months. On Tuesdays it is reserved for women only. Boys from the public elementary schools in the district are admitted every morning except on Saturday, from six to eight, at a charge of one penny.

A large refreshment and drill-room provides good, wholesome, cheap dinners or lunches, for the pupils and others, the public being also admitted, and great care is exercised to furnish food of good quality and well cooked, at reasonable prices.

The educational section is doing good work. The technical school is operated in connection with the science and art department, South Kensington, the City and Guilds of London Institute, and the Society of Arts.

Boys to be eligible for the technical day-school, must be over twelve years of age: must have passed at least the fifth Standard, or an equivalent examination; and must be the sons of parents whose income is under £200 per annum. The courses of study are arranged to meet the require-

ments of those who intend to follow either of the following trades or professions:

Carpenters and joiners,
Cabinet-makers,
Engineers, electrical engineers,
Smiths and metal workers,
Designers,

and any of the chemical industries.

The fees are one shilling per week, or ten shillings per school-term, the school-terms averaging a little over two and a half months each.

A limited number of boys are admitted whose parents' income exceeds £200 per annum; the fees being £8 8*s*. per annum.

A large number of boys are admitted on free scholarships, subscribed by friends and others, after a competitive examination, open to boys attending public elementary schools in certain districts.

There were last October about 400 boys attending the classes, of which 300 were in the junior section. The hours are from 9 A. M. to 4.15 P. M., with one hour intermission at dinner-time, and one-fourth hour recess in the morning. The boys are divided into four sections, and each boy receives thirty and one-fourth hours' instruction in the week, the subjects taught being mathematics, mechanics, practical plane and solid geometry, machine or building construction and drawing, experimental physics, free-hand drawing and designing, model drawing, special handicraft work, drill and swimming, the latter, however, being in addition to the thirty and one-fourth hours' weekly work.

After the course for the first year, the studies tend to become specialized. Thus, those inclining to chemistry give more attention to that subject, electrical engineers study magnetism and electricity, mechanical engineers apply themselves to mechanics, etc. In the third year, the students are still more particularly kept at special studies, perhaps only chemistry, or only metallurgy, or physics, etc., depending upon the subject selected.

The chief difficulty to be contended with in the day-

school, is that of inducing the parents to allow their boys to remain for a longer time than the first year. Too much cannot be said regarding the importance of the pupil receiving at least two, and, if possible, three years' technical school instruction, and it is readily seen that more than one year's study is necessary for them to become acquainted with even the elementary principles of the subjects taught.

At the time of my visit nothing had yet been actually done for girls in the day-schools, as there had not been sufficient accommodation for them in the buildings; but last October a junior section was just about being started for girls of from thirteen to sixteen years of age, who had already passed through the elementary schools.

It is at the evening classes that the greatest attendance is observed, and the most encouraging success. There are on the rolls about 5,000 students, but only about 2,500 are present at one time, as many come for only one or two hours in the week, say to one or two classes. The evening classes are open to both sexes of all ages.

Only those are eligible to the practical trade or technical classes who are actually engaged in the trades to which these subjects refer, unless an extra fee is paid. The practical trade classes are:

Tailors' cutting,	Cabinet-making,
Upholstery,	Engineering,
Photography,	Carpentry and joinery,
Plumbing,	Wood-carving.

The technical classes are:

Boot and shoemaking,	Electric lighting,
Mechanical engineering,	Instrument making and telegraphy,
Photography,	Laboratory and workshop practice,
Carpentry and joinery,	Plumbing,
Printing (letter-press),	Brickwork and masonry,
Electrical engineering,	Cabinet designing.

The science classes comprise:

Practical, plane and solid geometry,
Machine construction and drawing,

Building construction and drawing,
Mathematics,
Theoretical mechanics,
Sound, light and heat,
Magnetism and electricity,
Steam and the steam-engine,
Applied mechanics,
Chemistry, inorganic and organic.

The fees vary more or less for the different subjects in all three classes, and members of some classes have special privileges for other classes. In the practical trade classes the fees run from 5*s.* to 8*s.* 6*d.* per quarter; in the technical classes from 4*s.* to 7*s.* 6*d.* per session, and in the science classes they are generally four shillings per session, although in special cases they are higher, even up to fifteen shillings.

The art classes, which are held at Essex House, Mile End Road, teach free-hand and model drawing, perspective, drawing from the antique, decorative designing, modelling in clay, etc., drawing from life, etching, wood carving, repoussé work and engraving.

The musical classes teach singing, piano-forte and violin, and there are choral and orchestral societies and a military band. Fees from two shillings to nine shillings per quarter.

The general classes comprise:

Arithmetic, book-keeping, civil-service work in all its different departments, including excise, customs and telegraphy, short-hand, French, German, elocution, writing, Shakespeare class, London University examinations, land surveying and levelling, ambulance, nursing and chess. The fees are very variable, running from one shilling per quarter for chess, to twenty-one shillings for university examinations, but the ordinary subjects are from 2*s.* 6*d.* to four shillings.

There are special classes for females only in dressmaking, millinery and cookery, also in elementary studies, including reading, writing, arithmetic, etc., and in elocution. The fees run from 2*s.* 6*d.* to 7*s.* 6*d.* per quarter.

The gymnasium is very complete, a regular series of classes being organized under a chief instructor with assist-

ants, and certain evenings and hours are assigned to certain subjects. The fees are only 1*s.* 6*d.* per quarter, entitling the member to join any or all of the classes except boxing, for which an extra fee of sixpence is charged.

A junior section is provided for pupils from thirteen to sixteen years of age, and a ladies' gymnasium is held in Queen's Hall, for which the fees are one shilling per quarter. Each member of the gymnasium classes is provided with a locker in which to keep gymnastic attire, free of cost.

The staff of teachers in the education section is quite large, and very many are only specialists in certain subjects, coming just at the hours for those classes.

The social section of the People's Palace shows equal success with the other sections. During the year ending October, 1888, some 4,200 young men and women, between the ages of fifteen and twenty-five, joined the Institute, paying a subscription of 2*s.* 6*d.* per quarter, or 7*s.* 6*d.* for the year, for the young men; 1*s.* 6*d.* per quarter, or five shillings for the year, for the young women. The number for 1888–89 was undoubtedly still larger. These members have free admission to all concerts, exhibitions, shows, etc.; the use of the gymnasium, the billiard and game-rooms, and admission to the swimming-bath at the reduced charge of twopence and eligibility for election to membership in any of the various clubs and societies connected with the Institute. There are some twenty-one clubs, comprising a chess and draughts club, a debating society, a choral society, a military band, an orchestral band, a sketching club, an art society, a photographic society, a girls' social club; swimming, foot-ball, harriers, cricket, cycling and billiard clubs, etc. The funds of these clubs are deposited at the Institute office, and remain in charge of the trustees.

Teas, conversaziones with dancing, evening dances, etc., are given, mention being made, in the annual report, of two evening dances, the attendance, which is restricted to members and their friends, being 1,100 at one time and 1,400 at the other. The general quiet and good behavior at these festivities were the subject of very favorable comment.

The number of members belonging to the gymnasium is very large, and the attendance varies from about 300 per night up, occasionally, to as many as 800. Gymnastic displays are given and competitions with prizes. That special part of the social department relating to young women has, also, been very successful.

Excellent accommodation for the cricket and foot-ball clubs is provided by the corporation of the city of London, in the use of about ten acres of ground at a convenient site, within easy reach of the Palace by the Great Eastern Railway, on which tickets are issued to members of the clubs at reduced rates.

The annual report, previously quoted, states that over 1,500,000 persons had visited the palace during that year, 1887–88, and not the slightest mischief or ill-behavior had resulted upon the gathering together of these large numbers of poor people. The most serious difficulties have been in obtaining sufficient funds to carry out all the work that presents itself, and the want of full accommodation. Much as the People's Palace is doing, there is still a great future before it.

Among other English institutions, might be mentioned the Home Arts and Industries Association, formerly Cottage Arts Association, which was started some years ago by a few amateurs, opening Saturday classes for teaching artistic handicrafts to the working boys and men of their own neighborhood, and, as the success of the experiment became assured, the project was extended and enlarged, until it became necessary in some cases to employ professional aid, and finally to perfect and adopt the present organization.

Through the agency of this association, the number of classes has been greatly increased, and the philanthropic interest in the claims of handwork as a part of education has been widely developed. The object of the association is to spread a knowledge of artistic handwork among the people, and to develop by instruction the perceptive faculties and manual skill of the pupils and prepare them for entrance into trades, at the same time increasing their

resources and enjoyments. Its work is accomplished by the following methods:

(1) The organization of classes in which attendance is voluntary and teaching almost entirely so.

(2) The lending to these classes of good designs and plaster models, and the circulation of manuals and pamphlets on industrial and artistic education.

(3) The employment of honorary local secretaries to carry out the work in country districts.

(4) The maintenance of a central office and studios in London, where both voluntary and paid teachers can be trained.

(5) The publication of a yearly report recording the progress of the work and such successful experiments in teaching as may prove useful to class-holders.

(6) The holding of a yearly exhibition and sale in London, where the work done in the various classes may be compared and criticised, and certificates of merit, medals, etc., be awarded for progressive attainment.

The minor arts at present being taught in the local classes are: Drawing and design, modelling, casting, joinery, carving in wood and chalk, repoussé work in brass and copper, hand-spinning and weaving, embroidery, pottery and tile-painting, embossed leather work, mosaic setting and basket-making, bent iron and rug-making.

The association is sustained by contributions of members, working members' fees, donations, subscriptions, etc.

Classes are of two kinds—training classes and ordinary classes. The question whether pupils in ordinary classes are required to pay for their lessons or not, is decided by local considerations, but the classes are eventually rendered self-supporting by means of a percentage charged on the work sold. The first outlay is met by local subscriptions. The central classes require a fee of *2s. 6d.* per lesson, preference being always given to members of the association and to students who intend to assist in teaching.

The Guild and School of Handicraft is an organization which has for its object the application of art to industry, being a co-operative society of workmen, working out origi-

nal designs for sale. The effort is made to apply the Guild system of mediæval Italy to modern industrial needs and to the movement for technical education. In connection with this Guild, and dependent upon it, is a school of about 100 workingmen and boys. The lines of work at present undertaken by this Guild are working in wood and metal, decorative painting, and the complete furnishing, fitting and decorating of houses.

The Society of Arts, London, takes great interest in questions of elementary and technical education, and important papers appear from time to time in the pages of its journal. Among others I would refer to one by Mr. William Lant Carpenter, February 10, 1888; one by Mr. Swire Smith, on "The Technical Education Bill," February 24, 1888; and one on "Scientific and Technical Instruction in Elementary Schools," by J. H. Gladstone, Ph.D., F.R.S., November 29, 1889; also to the discussions on these papers. Prof. Silvanus P. Thompson read a paper on "Secondary and Technical Education" before the same Society, in February of the present year, in which the educational scheme of the Charity Commissioners, as propounded in virtue of the Act of Parliament of 1883, was rather severely criticised (see *London Engineering*, February 21, 1890).

This subject might be almost indefinitely prolonged. It is one of great and increasing interest, and the more it is studied the greater the accumulation of material. Educational questions are now being discussed everywhere, in all countries, with a vigor as never before. Public interest has been aroused to the importance of the matter and to the necessity of modifications and improvements in the methods of teaching and of subjects taught. The examples and information presented in these papers are not intended as much to serve as models, as to show what is being done in other places, for if improvements are to be carried out in our own systems of education, it is advisable that we study what is being done elsewhere, and avail ourselves of the experience there gained.

It is possible that the writer may be able to furnish supplementary papers on this topic from time to time as

may seem advisable, and he should be glad to see contributions from others.

Why cannot such Institutions as the FRANKLIN INSTITUTE, the Builders' Exchange, the Pennsylvania Art Museum, the Philadelphia Exchange for Women's Work, and others of kindred interest, form themselves into an organization and do work such as is being performed by the City and Guilds of London Institute and the Department of Science and Art in Great Britain, to advance the cause of trade and technical education? These organizations could elect delegates to come together for the purpose of discussing, advising and advancing this question, the representatives appointed from each body forming a "Department for the Promotion of Education in Pennsylvania." The special interest of the FRANKLIN INSTITUTE would be in technical and science classes, and in the promotion of the mechanical arts; that of the Builders' Exchange in the trades classes; that of the Pennsylvania Art Museum in art and design; that of the Philadelphia Exchange in special classes for women's work, etc.

The FRANKLIN INSTITUTE is now in a position with its Board of Trustees to receive funds in trust for special purposes of education and for awarding of prizes, premiums, scholarships, etc., and these trusts can be carried out in the names of the donors. Grants of state aid can be made for certain departments of education and some such organization as here suggested, if carefully and properly worked up, would become a great agent in the cause of technical and trades education.

THE METALLURGICAL ARTS AT THE PARIS EXHIBITION.

BY F. LYNWOOD GARRISON,
Delegate of the INSTITUTE.

[*Concluded from vol. cxxx, p. 125.*]

FIRMINY STEEL WORKS.

The exhibit of this company was one of the best of the steel works of central France. It contained a large number of iron and steel metallurgical products, some of which possessed peculiar interest, a series of cast irons were shown, some containing fifteen per cent. manganese, also chrome cast iron with twenty-five per cent. chromium; silicon-spiegeleisen with fifteen per cent. silicium and eighteen per cent. manganese.

Some of the products of the Rollet cupola furnace for refining iron were also shown. It is claimed that the iron made in this furnace contains but ·004 per cent. phosphorus. The so-called Rollet Process is essentially a remelting of pig iron with additions of iron ore, limestone and fluorspar in a cupola furnace. The Firminy Company have deservedly a high reputation for their excellent production of steel projectiles, axles, car and carriage springs, and particularly gun carriages. Agricultural tools are also extensively manufactured; a specialty is made of Siemens-Martin steel for rifle barrels, large quantities having been supplied for the famous Lebel rifle.

The Firminy Company claims to have been the first works in France to adopt the Siemens-Martin process, Eight furnaces are now in operation, about equally divided between acid and basic, the magnesite used in the latter coming from Styria. Since 1870, large quantities of this steel have been manufactured into heavy ordnance. An interesting series of samples of iron and steel united by the Verdee process and used for dies, shears, etc., were exhibited. By this process a steel face is cast upon a wrought-iron

body; the union of the two metals appears to be perfect, judging from the fractures.

Another specialty of this company is the manufacture of steel wire of exceptional tensile strength. They claim to be able to produce three-millimetre wire having a tensile strengh of 250,000 pounds per square inch. Some 2·7-millemetre steel wire exhibited was claimed to possess as much as 270,000 pounds per square inch. The Firminy Company were among the first to manufacture crucible steel shells, chilled and tempered, and recently they have acquired celebrity for their armor-piercing projectiles of chrome and tungsten steel. They claim to have special methods of tempering these steels, the details of which are kept secret. The exhibit contained a series of thirteen railroad tires of various sizes, the largest being nearly ten feet in diameter and weighing 1,540 pounds. Very large forgings are not made to any extent at Firminy, their largest hammer being only thirty tons; the comparatively small ones, however, which they make, appear to be excellent in every way. There is only one blast furnace at present in operation at Firminy, with a daily production of about ninety tons. The following are analyses of the ores used:*

Locality.	SiO_2.	Al_2O_3.	CaO.	*Fe.*	*Mn.*	*Ph.*	*S.*
Spiliazeza, Greece, .	2·0	—	2·2	35·0	19·5	0·03	0·02
Mokta el Hadid, Algiers, ...	6·0	1·0	1·0	58·5	1·5	0·03	0·02
Elba, ...	12·0	0·5	1·0	50·0	—	—	0·03

The following are analyses of the pig iron and spiegeleisen produced: †

	C.	*Si.*	*Mn.*	*Ph.*	*S.*
Foundry iron, ...	3·40	3·20	0·10	0·07	0·02
White forge iron, ...	3·20	0·40	1·02	0·07	0·07
Silico-spiegeleisen, ...	1·42	17·00	18·09	0·085	trace
Spiegeleisen, ...	4·00	4·50	15·00	0·07	0·01

COMMENTRY—FOURCHAMBAULT COMPANY.

These works belong to the central or Loire group. The company has a capital of 25,000,000 francs, and, like many of the other large establishments of the kind in France, was

* *Journal of Iron and Steel Institute*, November 2, 1889, p. 394.

† *Ibid.*, p. 395.

built up by combining a number of small concerns. The works are divided into two principal groups, the collieries and the metallurgical establishments. The latter consist of the blast furnace and foundries of Montlucon (Allier); the forges and wire works of Fourchambault (Nièvre); the steel works of Imphy, and the Fourchambault and Nevers construction works. There are six blast furnaces at Montlucon, producing over 50,000 tons per year, which pig iron is celebrated for its purity and general excellence.

The Fourchambault Wire Works were established in 1818, by the Boigues family; they produce from 3,500 to 4,000 tons of wire per year.

The fifteen-ton open-hearth (Siemens-Martin) furnaces, located at the same place, are three in number, and produce about 20,000 tons of steel per year.

The Imphy Steel Works contain three open-hearth and two crucible furnaces, with hydraulic cranes for handling ingots, etc. The entire production amounts to about 12,000 of ingots and 1,500 tons steel castings per year. These works were the first in France to develop the production of steel castings. The Imphy Works are celebrated for wagon springs and for most of the higher grades of various kinds of steel. The display which this company made at the Exhibition was particularly complete and illustrative of its productions. It was divided into three classes—metallurgical products, illustrations of the working of their mines, and models, etc., of public works (travaux publiques), for which this company had supplied material.

MARREL FRÈRES (Rive-de-Gier Works).

These works, located on the Loire, were specially laid out for the production of steel in large masses. They have cast ingots up to eighty-five tons in weight and claim to be able to cast them up to 140 tons. A new 100-ton hammer is about completed at these works, the principal dimensions of which are as follows:

Weight of the falling mass, ...	100 tons.
Weight of the anvil block, ...	800 tons.
Maximum height of fall, ...	6 metres.
Steam cylinder diameter, ...	2 metres.

This steam-hammer will be used with two 180-ton steam cranes and two others of fifty tons each. It is established in a large shed, in which there is already working a fifty-ton steam-hammer, along with 100-ton cranes.

The furnace plant consists of four thirty-five-ton open-hearth furnaces, from which are produced the large ingots for the manufacture of guns, armor plate, etc. They also have a crucible steel plant, and produce considerable quantities of chrome steel.

ST. LOUIS-MARSEILLES IRON WORKS.

This company is one of the largest and most important in the south of France. It has long been celebrated for the production of superior foundry and forge pigs, spiegel-eisens, ferro-manganese, silico-spiegel (up to fourteen per cent. silicon), ferro-silicon (up to fourteen per cent. silicon), and ferro-chromium.

The following analysis is of the ferro-manganese, made by this company:

	Per Cent.
Iron,	6·23
Manganese,	85·40
Silicon,	0·466
Combined carbon,	7·100
Graphitic carbon,	0·560
Sulphur,	trace
Phosphorus,	0·165
Copper,	0·060
	99·984

Ferro-silicon (made in blast furnaces of the above company):

	Per Cent.
Iron,	82·60
Manganese,	2·50
Silicon,	12·60
Combined carbon, Graphitic carbon,	2·10
Sulphur,	0·054
Phosphorus,	0·088
Copper,	trace
	99·942

Ferro-chrome (made in blast furnaces of the above company):

	I.	*II.*
Chromium,	61·23	35·97
Iron,	30·17	57·28
Manganese,	1·35	1·20
Carbon,	6·07	4·21
Silicon,	1·11	1·21
Phosphorus,	0·05	0·03

It seems that it is very difficult to obtain these alloys containing over sixty-five per cent. chromium in blast furnaces; the richer ones are usually made in crucibles. Messrs. Holtzer & Co. have obtained some with as much as eighty per cent. chromium and eleven per cent. carbon in this manner.

LONGWY IRON AND STEEL WORKS.

These works, one of the most important in the eastern district (Meurthe-et-Moselle and Luxemburg) were established under their present management in 1880, with a capital of 15,000,000 francs, afterwards increased to 20,000,000. The Longwy Company has a number of different establishments, including the three blast furnaces of Mont St. Martin, the three blast furnaces of Prieuré, the basic Bessemer steel works at Longwy, and one or two smaller establishments. The works, as a whole, cover an area of thirty-nine acres, and have, besides, important concessions in iron ore properties. The company own the Mont St. Martin, Herserange, Moulaine and Valleroy mining tracts, and have an interest in those of Hussigny and Godbrange. Besides the ore from their own mines, the company use a certain quantity of Luxemburg and Bilbao ore to produce special grades of foundry iron. In making basic pig, ores from different sources are used. The following analyses are averages of a large number of samples taken on delivery at the furnaces.

	Iron.	Manganese.	Silicon.	Lime.	Alumina.	Sulphur.	Phosphorus.
Longwy—							
Hussigny red,	39	0·20	12·5	8	7	0·20	0·7
Herserange,	38	0·15	13	9	6	0·30	0·7
Godbrange,	37	0·15	15	9	7	—	0·6
Coulmy,	42	0·25	17	4	7	—	0·6
Hussigny lime,	28	0·15	10	22	5	0·25	0·5
Herserange lime,	26	0·15	10	24	5	0·25	0·5
Luxemburg—							
Sauvage,	42	0·15	13	6	7	—	0·5
Rumelange gray G,	35	—	8	14·5	7	0·05	0·7
Rumelange gray W,	34	—	8	15·5	6·5	0·10	0·6
Rumelange gray K,	33	—	8	17	6·5	0·10	0·6
Rumelange gray P,	34·5	—	8	16	6	—	—
Rumelange gray B,	33	—	8	17	7	—	—
Rumelange yellow K,	38	—	5	13	5	0·15	—
Schifflange yellow S,	29·5	—	9·5	22·5	2	0·15	—

The following table gives the principal data of Longwy Company's blast furnaces. The first three are the Mont St. Martin, the next two the Prieuré furnaces, the sixth the Longwy, and the seventh the Moulaine furnace.

Blast Furnaces.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.
	ft.	*ft.*	*ft.*	*ft.*	*ft.*	*ft.*	*ft.*
Height,	61·0	60·0	59·5	62·2	62·2	72·2	60·7
Diameter at top,	15·1	13·4	12·3	15·1	15·4	15·4	9·2
Diameter at bosh,	21·3	16·1	18·0	19·7	19·7	23·0	16·7
Diameter at crucible (high),	10·5	9·8	7·2	8·0	8·0	8·2	8·2
Diameter at crucible (low),	8·2	9·8	4·9	7·4	7·4	8·2	8·2
Contents in cubic feet,	13·420	9·040	9·465	12·290	12·290	16·950	8·617
Hot blast stoves — C=Cowper; W=Whitwell,	5 C	4 C	—	3 W 1 C	4 W	6 C 4 lar. 2 sm.	Cast-iron pipes.
Number of tuyeres,	4	4	4	4·	4	4	—
Pressure of blast in mm. of mercury,	11-12	10-11	—	10-11	10-11	11-12	—
Temperature of the blast,	—	1370° to 1480° F.				—	—
Daily production of basic iron in tons,	75	55	—	60	60	80	—
Date when furnaces were put in blast,	1880	1887	Out of blast.	1885	1884	1889	Out of blast.

The limestone used for the furnace is obtained from Saint Charles and Bellevue, the former carrying 2·5 per cent. silica and three per cent. of alumina, the latter four per cent. silica and 3·25 per cent. alumina, both containing about fifty-two per cent. of lime. The Mont St. Martin blast furnaces have been specially adapted for the basic process. The following are analyses of the different grades of pig iron produced by these furnaces:

Grade.	Manganese.	Carbon. Comb.	Carbon. Graph.	Silicon.	Sulphur.	Phosphorus.
Special foundry No. 1,	1·30	3·20	0·40	2·70	0·02	0·09
Special foundry No. 2,	1·10	3·05	0·50	2·30	0·04	0·07
Special foundry No. 3,	0·90	3·00	0·60	1·80	0·06	0·06
Special foundry No. 4,	0·85	2·50	1·30	1·40	0·09	0·06
White basic,	1·50	3·00		0·20	0·04	2·00
Mottled basic,	2·00	3·20		0·35	0·02	2·20

The analyses of the last two samples (basic pig) are interesting, as they are supposed to combine all the elements which constitute an ideal basic pig, viz: low silicon, very low sulphur, high phosphorus, and a moderate amount of manganese. The following analyses of the slag obtained from these furnaces will be of interest in this connection:

	Silica.	Alumina	Protoxide of Iron.	Protoxide of Manganese.	Lime.	Sulphur.
Vitreous basic,	32·5	16·5	1·4	1·6	46·0	0·8
White basic,	31·4	14·4	0·9	1·1	50·0	1·1
Yellow basic,	31·5	14·9	2·6	1·5	48·5	1·3
Black basic,	32·2	15·0	3·0	2·4	45·0	1·4
Foundry,	33·0	17·0	1·3	—	46·5	—
Foundry,	34·0	14·0	1·3	1·0	47·0	—

The pig iron is conveyed direct, while still liquid, to the basic Bessemer converters, which are located between the blast furnaces and the principal rolling mill. The three fifteen-ton converters are arranged around the same pit and are served by the same central casting crane, assisted by three primary and two secondary ingot cranes. The daily output of the three converters is from 250 to 300 tons, or a weekly production of from 6,000 to 7,000 tons. The basic linings of the converters last from 160 to 170 blows, the plugs from sixteen to twenty-five blows. The dolomite is calcined in three cupolas with natural draught, the firing lasting eight hours; the whole charge of the cupola is drawn at one time. From sixty to seventy tons of basic slag are poduced daily, carrying from fifteen to 16·5 per cent. of phosphoric acid. It is ground and sold as a fertilizer for

about thirty-five francs per ton at the works. The dolomite used for the basic lining is obtained from Ciney and Liége, the former containing about 0·8 per cent. silica, two per cent. alumina and iron, and ninety-six per cent. lime and magnesia, the latter 1·5 silica, 2·3 alumina and iron, and ninety-four per cent. lime and magnesia.

The following diagram (*Fig. 20*) shows the order of the elimination of elements in the pig under treatment in the basic Bessemer converters. The next diagram (*Fig. 21*) shows the composition of the slag during the operation.

The Longwy Company has adopted a scale of grades for their steel, and publishes the following table of tests and analyses to show the quality. The tests are made with round forged bars, sixteen millimetres in diameter, of 100 millimetres in length, the analyses being approximate averages:

Scale.	Tensile Strength. Kg. Per Sq. mm.	Elongation. Per Cent.	Manganese.	Carbon.	Phosphorus.
No. 1, hard,	75 to 70	12 to 14	0·1 to 1·2	0·3 to 0·35	about 0·1
No. 2, hard,	70 to 65	14 to 16	0·85 to 1·0	0·26 to 0·3	about 0·1
No. 3, medium,	65 to 60	16 to 18	0·7 to 0·85	0·22 to 0·26	about 0·1
No. 4, medium,	60 to 55	18 to 20	0·6 to 0·7	0·18 to 0·22	about 0·1
No. 5, soft,	55 to 50	20 to 22	0·5 to 0·6	0·15 to 0·18	—
No. 6, soft,	50 to 46	22 to 24	0·6 to 0·8	0·10 to 0·12	0·08 to 0·01
No. 7, very soft,	46 to 42	24 to 26	0·4 to 0·6	0·09 to 0·1	0·08 to 0·01
No. 8, extra soft,	42 to 38	26 to 28	0·25 to 0·4	0·08 to 0·09	0·05 to 0·08
No. 9, special,	under 38	over 28	0·25 to 0·3	0·08	0·03 to 0·05

The ingots made at Longwy are taken direct to the rolling mills, of which there are several. The appliances include a universal rolling train with rolls twenty-nine and one-half inches in diameter, also a train of three high rolls. There is a train of reversible twenty-six inch rolls, driven by a 2,500 horse-power engine. There is a fifteen-ton steam-hammer in the same building, with a reheating furnace, and crane for handling the ingots.

The reheating furnaces are worked in connection with vertical boilers, heated by the waste gases. The works are lighted by electricity. A testing machine of 100 tons, of the Marié type, is employed for flexion and traction tests, and another machine of the Trayvou type is employed for compression and other tests.

PONT-À-MOUSSON (Meurthe-et-Moselle).

These are one of the most important smelting works in the east of France; they have four blast furnaces, each making about forty-five tons of foundry pig daily, the most of which is made on the spot into pipe. The pipe foundry is one of the largest of the kind in France, having twenty-five vertical casting pits, and capacity for making nearly

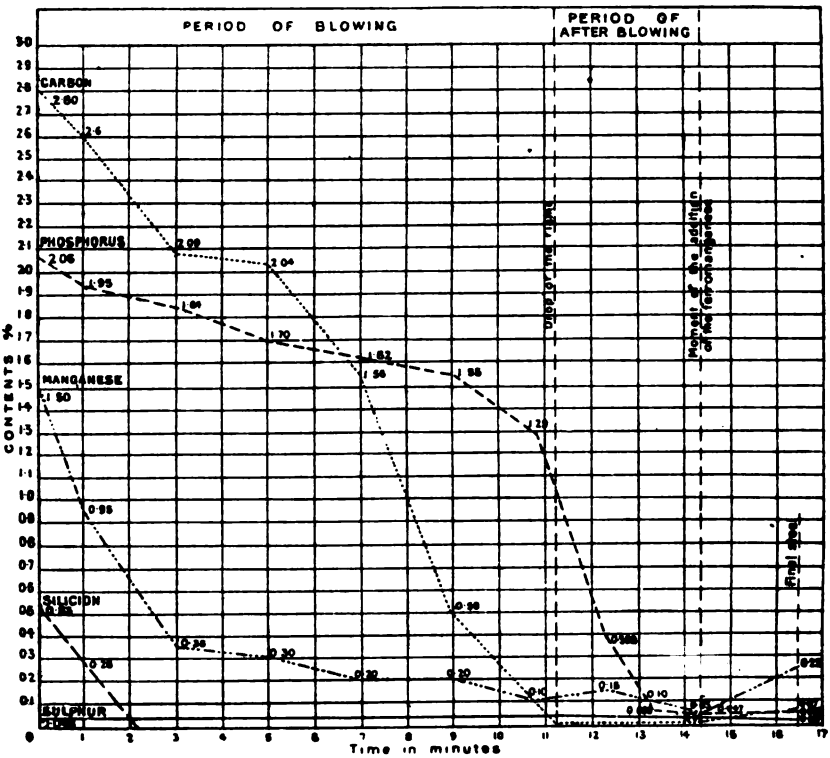


FIG. 20.

two miles of pipe per day, varying from 1½ inches to 6 feet in diameter and 13 feet in length. An example of the largest work was shown at the Exhibition, in the form of a socketted T-pipe, 13 feet long and 6 feet internal diameter in both limbs, which were moulded without a pattern and cast vertically.

The Pont-à-Mousson Company is one of the most flourish-

ing concerns in France. It was established in 1856 by Mansuy & Co., with a paid-up capital of 1,600,000 francs, and in 1886 was formed into a company with a capital of 2,047,500 francs. It is stated that since their foundation some 6,000,000 francs have been spent on the works, the greater part of which was drawn from the profits. In 1888, the total length of cast pipe produced was 547 miles, about

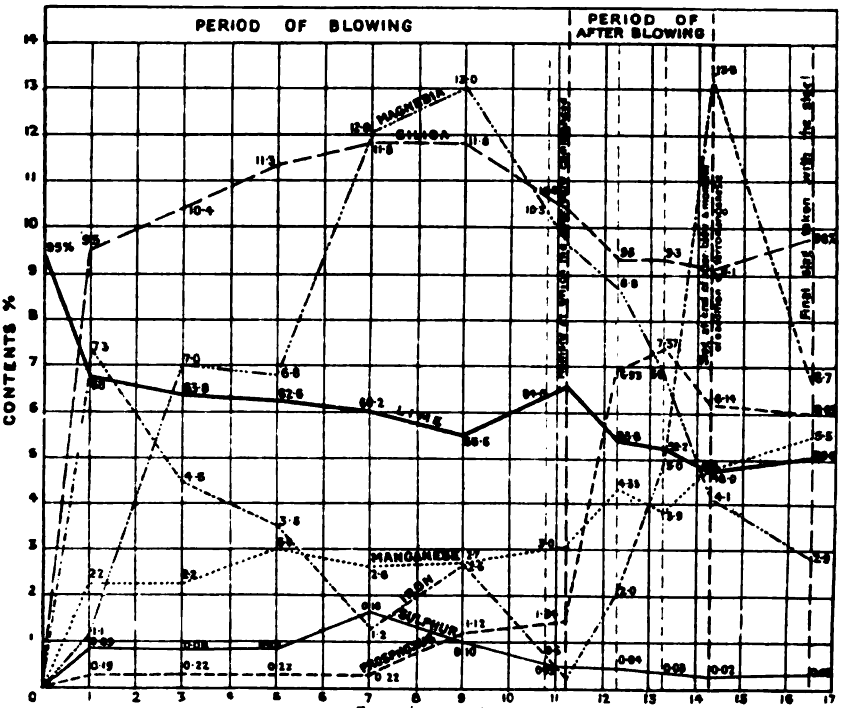


FIG. 21.

one-fourth of which was exported. The whole plant gives employment to over 1,300 men.

DENAIN AND ANZIN COMPANY.

The works of this company are located in the northern district near Valenciennes. They consist of ten blast furnaces and two Bessemer plants of two ten-ton converters each besides numerous puddling and reheating furnaces. Four of the blast furnaces were represented by models at the Exhi-

bition. They have Whitwell stoves, and pneumatic hoists for ore and coke. The most interesting part of these furnaces is the device for getting rid of the slag, which is granulated by running it into a large semi-circular basin placed in front of the furnaces, which receives the waste water from the tuyeres and other cooling appliances. The basin is divided by a middle wall, so that one-half is allotted to each pair of furnaces. The granulated slag is removed by a bucket elevator into cars and taken to an adjoining works, where it is converted into bricks and artificial stone. These bricks have a good surface, resist frost, and, although very strong, are sufficiently open texture to allow nails to be driven into them.* The total annual production of pig-iron at these works is about 150,000 tons, of which 120,000 tons are converted into steel and malleable iron in the company's own works. They employ over 4,000 men, which, with their families, form a settlement of over 10,000 persons in the vicinity of the works. The company have established schools, hospitals, infirmaries, etc., for their welfare, which seems to be considered to an exceptional degree.

The following grades of iron and steel are made at the Denain & Anzin Works:

Grade.	*Carbon. Per Cent.*	*Tensile Strength. Kilogs. per mm.*	*Elongation.* † *Per Cent.*
1 Extra soft homogeneous iron,	·04 to ·06	33 to 35	29 to 31
2 Soft homogeneous iron, . . .	·06 to ·08	35 to 37	27 to 29
3 Merchant iron, ...	·08 to ·12	38 to 40	25 to 27
4 Soft construction steel, . . .	·15 to ·20	42 to 46	22 to 25
5 Medium soft construction steel,	·20 to ·30	45 to 50	18 to 22
	Limit of elasticity.		
6 Steel for springs, etc., ...	39 to 41	59 to 62	15 to 20
	kilog. per mm.		
7 Steel for springs, etc., ...	45 to 48	65 to 70	10 to 15
8 Extra hard tool steel, ...	—	70 to 80	8 to 10

VALENCIENNES WORKS (Nord).

The foundries, forges and steel works of Valenciennes, in the Department of the Nord, are situated between the Escaut and the line from Valenciennes to Cateau. They cover an area of more than 60,000 square metres. Some

* *Engineer* (London), November 8, 1889, p. 387.

† Calculated on a bar 200 millimetres long.

60,000 tons of steel are annually produced by the Bessemer and the Siemens-Martin processes of manufacture. The works employ 1,500 hands, and are fitted with steam-hammers of fifteen, ten and three and one-half tons, respectively, a rolling-mill for the production of plates, a reversing rolling-mill, rail-testing machinery, foundries, a forge with twenty-eight puddling furnaces, twelve reheating furnaces and four trains of rolls, capable of producing 50,000 tons of iron per annum. At Trith-St.-Léger, near Valenciennes, the company own another forge, with fifteen puddling furnaces and auxiliary reheating furnaces and rolling-mills. They have also four blast furnaces at Jarville, near Nancy, where they produce annually about 100,000 tons of pig iron.

The Valenciennes Works use the oölitic ores of Chavigny, which are smelted at Jarville, some addition of manganiferous ore being made in the blast furnace. A proportion of phosphoric pig from England and Germany is used in the converters. The new large rolling mill recently erected at these works consists of three pairs of twenty-four-inch rolls in one line, driven directly by a two-cylinder horizontal engine of 5,000 horse-power. The feeding arrangements are very complete, including line rollers on both sides, carriers for shifting the blooms from groove to groove at each pass.

Sixteen Gjers soaking pits, with cranes for working same, are now in operation at these works, this establishment being one of the few in France in which the soaking pit has been adopted.

NEW PROCESSES.

Under the head of new iron and steel processes, or perhaps, to speak more exactly metallurgical devices, which have been introduced in France, within the last ten years we might place three. The Valton-Rémaury system of chrome iron-ore linings for open-hearth furnaces, the so-called Robert process and the Rollet process for producing purified castings. The Robert process, however, can only be called new by courtesy, for to any one familiar with the development and early history of the Bessemer process, it is evident that it is simply a resurrection of one or more of

the ideas and methods used by Bessemer in developing his process as it now exists.

CHROME IRON-ORE LININGS.

The use of these ores as neutral linings for open-hearth furnaces seems to have been experimented with in several of the works on the Continent and in England for a number of years past. The works of Bell Bros., at Port Clarence, near Middlesborough, England, appear to have gone into the thing rather more extensively than elsewhere, but with what results I have been unable to determine.

The ore is first roasted, then made into bricks or else broken into lumps (none larger than about three inches in diameter), which are bound together with lime mortar. Such bricks are very expensive, but last a long time, and, it is claimed, in the long run, are much more economical than dolomite linings. Bricks, however, need not be used, as the hearth and sides of the furnace can be lined with a mixture of three parts chrome iron-ore and one of lime, as free as possible from silica. The chrome ore should be as rich as possible, containing from forty to forty-five per cent. of Cr_2O_3.*

It is claimed that this lining resists equally well silica and silicious slags and remains neutral to strong bases. At the Putiloff Steel Works near St. Petersburg, Russia, it was found that the chrome-ore linings did not work well unless covered with a layer, about two inches thick, of dolomite or quartz; the dephosphorization being effected by this means and by the use of lime or dolomite fluxes. It is stated † that in the Finnish and Russian open-hearth steel works chrome-iron ore beds are no longer used, as it was found that the larger lumps broke away from the material composing the furnace bed and rose through the molten metal, thus causing the bed to wear away rapidly. This breaking away of the larger lumps does not take place at once, but only after the furnace has been in operation some time. On the other hand, Rémaury claims that one furnace at Alais,

* *Iron* (English), September 30, 1887, p. 304.

† *Journal of the Iron and Steel Institute*, No. 1, 1889, p. 341.

in France, has been running with the same bottom for three years.

At the Port Clarence Works (Bell Bros.) the charges, I understand, consist of ten tons of pig iron, three tons of iron scrap and two tons of steel scrap, to which afterwards limestone and iron ore are added. After melting from two to five hours, the slag is tapped off, carrying with it about fifty per cent. of the phosphorus. More iron ore is then added. The time required to convert one charge varies from nine and one-half to ten hours. From 0·7 to 0·8 per cent. of ferro-manganese is added in the casting ladle. It is claimed that the steel thus produced contains only from 0·02 to 0·04 per cent. phosphorus—a small amount of chromium seems to be taken up by the steel. The pig iron used averages about the following composition: Carbon, 3·6; silicon from 1·8 to 2·5; phosphorus, from 1·5 to 1·6; sulphur, 0·02 to 0·06, and manganese, 0·5 to 0·6 per cent.

ROBERT–BESSEMER STEEL PROCESS.

The Robert converter, or, as I have termed it heretofore, the Robert-Bessemer converter,* is a slight, if any, modification of what was known as the Walrand converter, which was erected at the Stenay Steel Works (Meuse), France, in September, 1885.† The Walrand converter seems to have been successfully operated, for several years with both acid and basic linings, in a number of places in France and Germany. It was not, however, until given the name of Robert or Bookwalter steel process, that it attracted any considerable attention. As this converter is fully described in the above-mentioned paper, it will be unnecessary to give any details in this place, except to mention that the converters have a D-shaped cross section, are mounted on trunnions like a Bessemer converter (*Figs. 22* and *23*). The tuyeres are all in the same horizontal plane on the flat side of the converter, with their axes at various angles to its horizontal axis. The converters are mostly

* "The Robert-Bessemer Steel Process," *Journal of the Iron and Steel Institute*, No. 2, 1889, p. 266.

† *Journal of the Iron and Steel Institute*, No. 2, 1886, p. 659.

small—under three tons as a rule. *Fig. 24* (*plate*) shows the construction and plan of the Walrand converter used at Stenay in 1885. The only difference between this converter and the Robert seems to be the number and size of the tuyeres; in other respects, the two forms appear

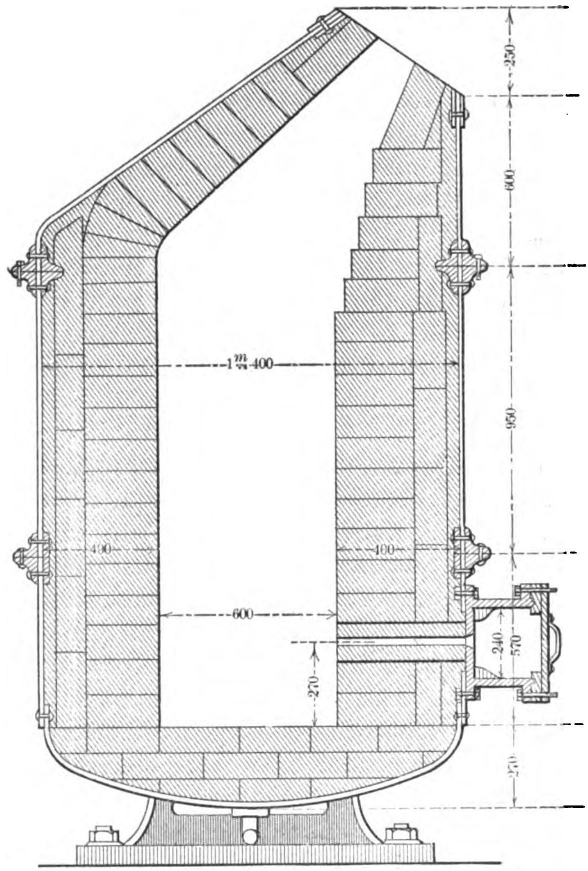


FIG. 22.—Robert-Bessemer Converter. (Vert. Section.)

to be identical. In the Walrand converter, the tuyeres are four in number, 3 inches wide by 1¼ inches deep, and are placed three or four inches below the surface of the metal bath. In the Robert converter, the tuyeres are more numerous, are round, with a diameter of about one and one-half inches, and placed just below the surface of the bath, so

Jour. Frank. Inst., Vol. CXXX. October, 1890. (*Garrison.*)

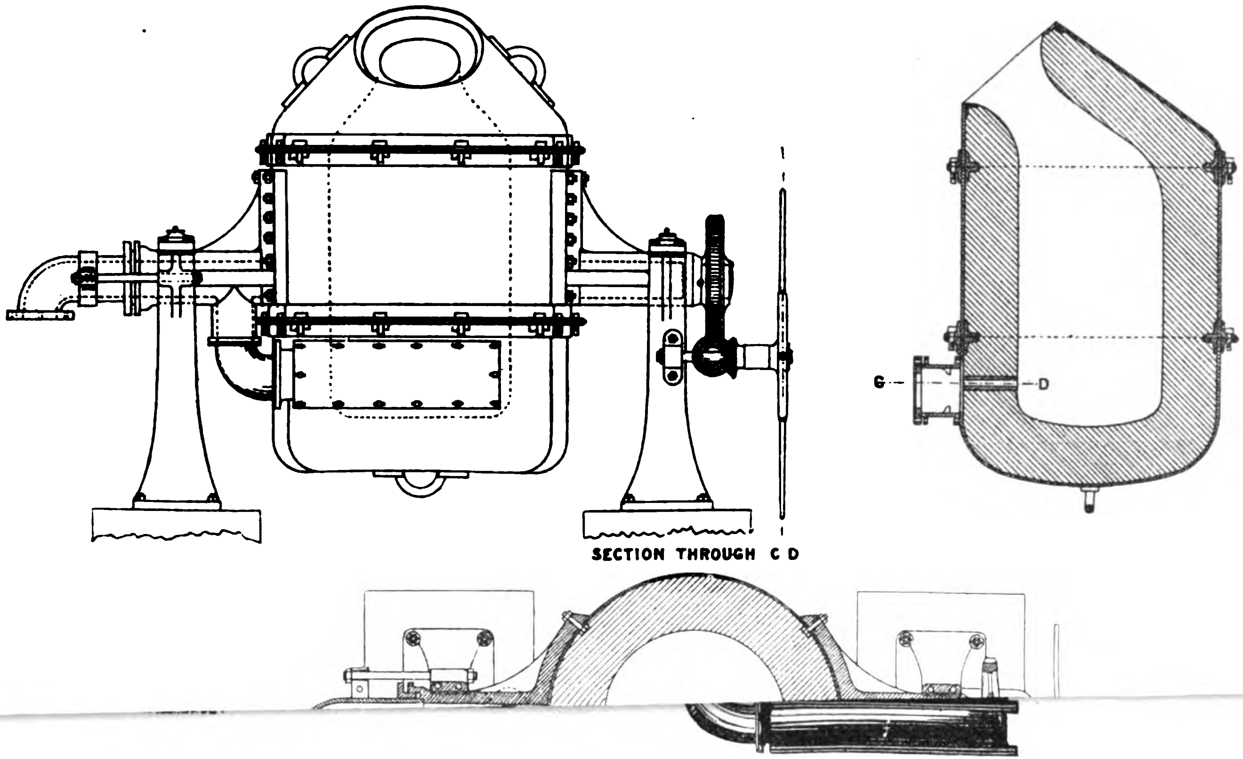
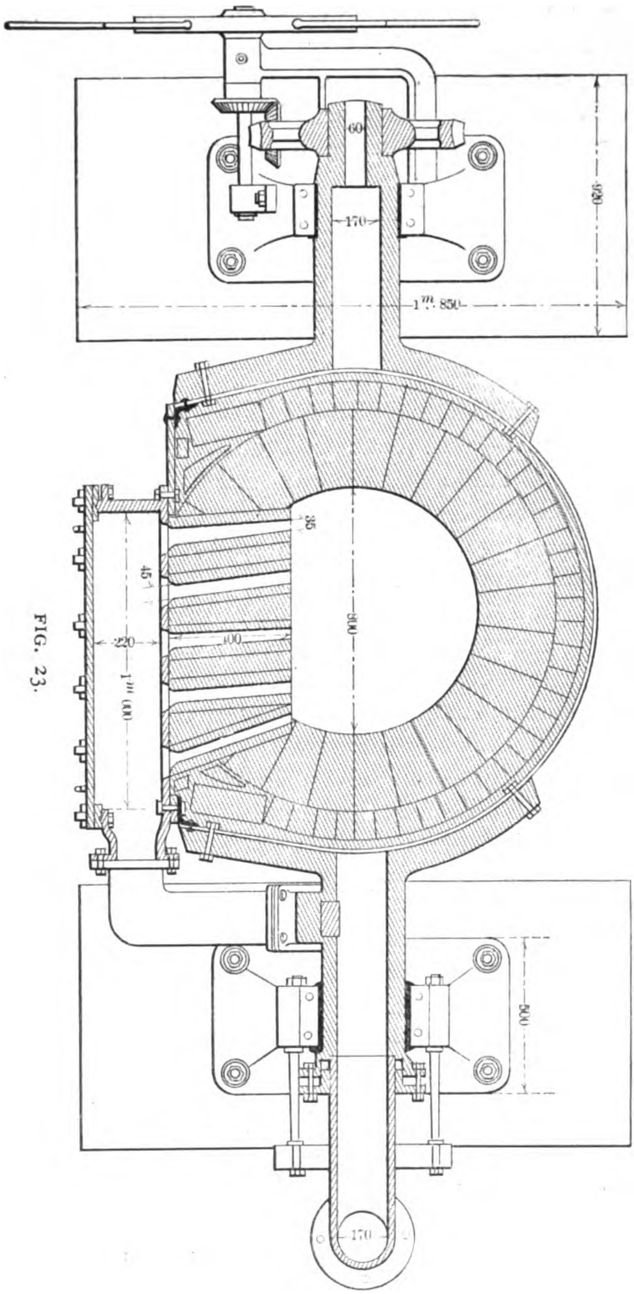


FIG. 25. Adamson's Converter.



Robert-Bessemer Converter. (Plan.)

FIG. 23.

that when the blast is turned on it will impinge on the surface of the metal. In *Fig. 25*, we have shown a form of converter patented in England by Daniel Adamson in 1863*. In the specification, Adamson states that the tuyeres may be placed horizontally or diagonally towards the bottom of the converter. In another description of this converter, it is stated that when only small amounts of metal are used the inclination of the converter can be so varied as to bring the tuyeres near to a horizontal line.† This expedient is sometimes resorted to with the ordinary Bessemer converters; it can, therefore, hardly be considered uncommon.

What is claimed as novel in the Robert converter is "a combination of several parts in a converter having a flat side in which flat side are ranged the tuyeres in a plane horizontal to the axis of the converter, and all in the same plane." "The tuyeres having an inclination to enable a rotary motion to be imparted to the metal bath and being so disposed that by tilting the converter in the trunnions the depth of the metal over the tuyeres can be regulated."

Without commenting upon the alleged novelty of the Robert converter, it should be stated that it seems to have produced excellent results wherever put in operation; but whether this is due to any new principle or to any combination of several old ones, I am unable to determine. It is, however, as Sir Henry Bessemer states,‡ "unquestionably true that in certain cases small converters can be used to great advantage."

Some of the claims for the Robert converter seem reasonable enough, while others are, as far as I know, unsubstantiated.

For instance, it is claimed, with the Robert converter, that the loss of iron from the cupola to the ingot is only from twelve to thirteen per cent. in acid lined and from sixteen to seventeen per cent. in basic lined. I have heard it stated on good authority that with some of the acid-lined

* English patent, December 22, 1863, No. 3,233.

† Adamson's Converter, *Engineer* (London), 1864, vol. 18, p. 147.

‡ *Journal of the Iron and Steel Institute*, No. 2, 1886, p. 639.

converters used in this country this loss was reduced under ten per cent.

This is difficult to believe for several reasons, but chiefly to what appears to be an abnormal amount of ***brown smoke*** produced during the blow. M. Gautier states that in France, with small converters, no one could make a ton of steel with less than twenty per cent. waste of pig iron.* In small converters the oxide of iron has not time to burn the other elements, so it goes off in red or brown smoke, hence the greater waste. The exceptionally high temperature which is obtained in the Robert and in all small converters is due to a great extent to the extra oxidation (burning) of the iron. "It is a practical fact that the weight of pig iron required to make a ton of steel in small converters was much more than that required in a converter of the ordinary size.† It is claimed that the Robert is the only side-blown converter which is suitable for the basic process, as the large amount of slag produced would soon choke up a similar fixed converter.

ROLLET PROCESS FOR PRODUCING PURIFIED CASTINGS.

The process of fining castings, as here described, is intended to be auxiliary to the manufacture of special qualities of steel, its object being to eliminate sulphur, phosphorus and silicon from the castings. It consists in melting castings or pig, or maintaining them at a very high temperature under a double action, slightly reducing and slightly oxidizing, in the presence of a slag obtained by admixtures of limestone or lime, iron ores and fluorspar, in proportions depending on the quality of the pig or castings employed. The apparatus employed for this purpose, *Fig. 26*, is a blast furnace or modified cupola, using coke and a hot blast. The burdens are introduced in the same way as in blast furnaces and cupolas. It consists of a part *A*, an independent shaft *C*, several rows of tuyeres *FFF*, a siphon arrangement *SS*, for separating metal from slag, and of a front chamber *M*. Externally, it is composed of sheet iron

* *Journal of the Iron and Steel Institute*, No. 2, 1886, p. 673.

† Gautier, *Journal of the Iron and Steel Institute*, No. 2, 1886, p. 673.

and steel; internally, at the bottom, it is lined with any suitable refractory material, preferably with magnesia. It is cooled externally at all parts liable to injury by currents of cold water. The tuyeres are arranged in several rows, above one another. They are water tuyeres and project into the furnace. The hearth is situated as near as possible to the lower row of tuyeres. A single hole *K*, serves for tapping both the metal and the slag. In tapping, the metal is separated from the slag by means of the siphon, *SS*, which is so arranged in relation to the hole *QO*, as to prevent the blast from blowing through. The metal flows out at *LSS*, and the slag at *QO*. The tuyeres are arranged in several rows, to facilitate the melting of all the substances charged. They are arranged one above the other, so as to raise the temperature along a line passing in front of their nozzles, and so ensure a good working. They project inwardly, so that their ends may not get clogged by the colder and more decarburized matters which descend along the walls. The approximation of the lower row of tuyeres to the hearth is intended to prolong the action of the blast upon the slag, which at that point is light and frothy, and upon the metal which flows down through it, so as to ensure a greater elimination of phosphorus. The separation of metal from slag, as soon as both are removed from the action of the blast, is carried out so as to prevent the phosphorus already eliminated from going back into the metal, a result which would be produced by the reduction of the phosphoric acid of the slag by the action of the coke and the metal. Another object of the separation is to prevent too great a recarburization of the metal. The temperature of the blast is as high as possible, viz: 400° at least, so as to ensure the good action of the tuyeres. These would otherwise get clogged by the slag, which is always very refractory and stiff, or by the decarburized metal which forms at their ends. The furnace being in operation, metallic iron is formed, by the action of the blast and the iron ore upon the cast iron or pig, on the bottom part of the walls, where it adheres, thus forming, after working twenty-four to thirty-six hours, a substitute for the original lining.

The furnace may thus be run for an indefinite period of time. But it will be preferable, after two or three months' working, to reline the upper portion, as the bricks will then

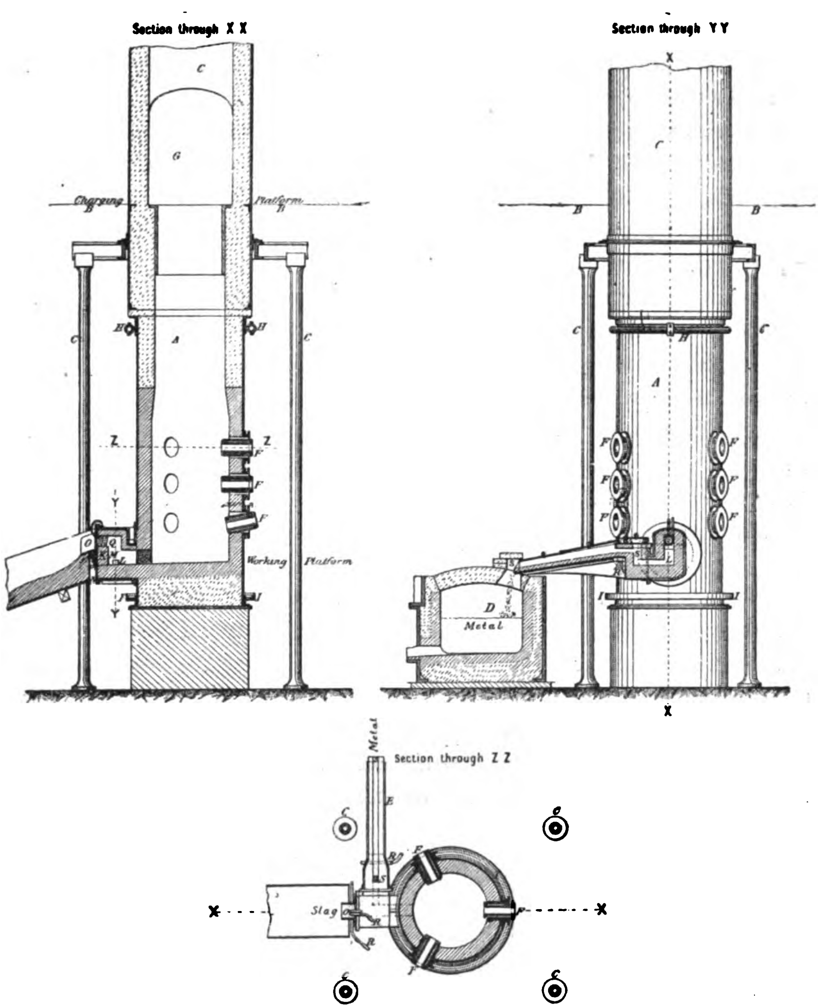


FIG. 26.—Rollet Cupola.

be worn out by attrition. The production is from fifty to seventy five tons per day of twenty-four hours. The product obtained usually has a white, spongy appearance. The slags are yellowish white. They contain almost all the

phosphorus eliminated from the cast iron or pig in the state of phosphoric acid, and only a part of the sulphur in the condition of sulphide. The elimination of the sulphur is complete up to ninety-nine per cent., and even more. That of the phosphorus amounts to eighty or eighty-five per cent., in exceptional cases to ninety per cent., and more. And as the recarburizing action of the coke sets a limit to the decarburization of the cast iron, a casting once treated may be treated again in the same manner, by which means, beginning with any sort of castings, a carburized iron purer than the best Swedish iron used for cementation can be obtained. The carburized iron thus obtained may be used in Siemens furnaces with acid bottoms, where it may be employed to a greater extent than cast iron or pig, and so diminish the weight if wrought iron be required. It may be puddled, in order to produce iron destined for melting on acid bottoms, for crucible melting, or for cementation. It can also be used as cement steel for crucible melting, mixed with iron.*

This process or metallurgical device for purifying iron castings appears to be as yet in but an elementary stage of development. I have not, at least, seen or heard of any reliable data obtained from a steady prolonged use of the furnace. It would therefore appear premature to pass an opinion upon its merits.

I think it very doubtful, however, if such a large amount of phosphorus can be eliminated in this way, although I believe a large proportion of the sulphur might be so eliminated.

In concluding this report I cannot but feel how incomplete it is and how little it shows of the advances France has made in the iron and steel industries. If the great Paris Exhibition of 1889 teaches us nothing else, it will have fulfilled its mission in showing the world the remarkable thrift and industry of the French people. France has had enough disasters within this century to have forever ruined any country similarly situated, and yet we see her to-day, while perhaps not so powerful and rich, as vigorous and enter-

* *Jour. Iron and Steel Institute*, No. 1, 1890, p. 154.

prising as ever. It is easy to understand how so small a country as England should be rich and powerful, for she has had no disastrous wars to sap the strength, and within her comparatively tiny borders are vast stores of coal and iron, to say nothing of the strong and vigorous race which develop and use them. The mineral resources of France, on the other hand, are, as far as we know, very much more limited, and as we have seen, a very large proportion of the coal and ores she consumes are imported. Truly, Helvetius has said, "*le bonheur des peuples dépend et de la félicité dont ils jouissent au dedans et du respect qu'ils inspirent au dehors.*"

PRECIOUS STONES.

BY GEORGE F. KUNZ.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *February 17, 1890.*]

[*Concluded from vol. cxxx, p. 182.*]

The families with iridescent interior layers are the following: among the cephalopods, the nautilus and the ammonites, the latter wholly fossil. In both these groups the removal of the outer layers of the shell reveals the splendid pearly surface beneath. Modern nautilus shells are often "cleaned" with dilute acid to fit them for use as ornaments, and frequently this is done partially, elaborate patterns being formed by leaving parts of the white middle layers to contrast with the pearly ground. Among the fossil ammonites, the same effect is produced, very often naturally by decay of the outer layers; and no artificial pearl work can equal the richness of color displayed by many of these specimens.

The subdued beauty and purity of the pearl now renders it even more popular than before, and it never commanded such high prices as during the past ten years. At present no jewel is considered in quieter or better taste than the pearl. This unusual demand has had the effect of greatly stimulating the search for them, especially on the west coast of Australia, Thursday Island, the Sooloo Archi-

pelago, in Ceylon, and the Persian Gulf, and also along the coast of Lower California.

The demand has included pearls of all colors except the inferior yellow. The fine black pearls from Lower California have been in great request, single ones bringing as much as $8,000. And with these black pearls are found many beautiful gray and grayish-brown ones. The different fisheries of the world produce fully $1,000,000 worth annually, of which our Lower California fisheries have yielded fully one-sixth. Kentucky, Tennessee and Texas have given us over $10,000 worth of pearls per annum, derived from the fresh water unios, and during 1889 at least $30,000 worth of pearls were found in one district in Wisconsin, many of which were remarkable for their brilliant and curious tints, red, purple and metallic.

The subject of artificial gems is at present of considerable interest, as furnishing an example of the surprises which the modern science of chemistry is constantly giving us. In 1886, there appeared in the Paris market certain stones which had been offered for sale by a Geneva house as rubies from a new locality; subsequently it was said that they were obtained by the fusion of a large number of small rubies, worth at most but a few dollars a carat, into one gem worth many times that amount. An examination proved that they were not the product of fusion, which would have resulted in the formation of a substance lower in specific gravity and less hard than a ruby; but that they were artificial stones, and had been formed by heat, not from rubies, but evidently from passing an aluminate of lead in connection with silica into a silicious crucible, the silica uniting with the lead to form a lead silicate, and liberating the alumina, which crystallized in the form of corundum. The difference between these stones and the true ruby was very apparent, owing to the presence of a large number of spherical bubbles, occasionally some pear-shaped, and a stringy internal structure, showing how the bubbles had moved. Mr. Ebelmann, at Sèvres, over forty years ago, and now M. Fremy, of Paris, after fifteen years' experimenting, has, with the assistance of M. Verneuil, suc-

ceeded in obtaining large numbers of beautiful crystals, one obtained after many experiments, and conditioned largely upon the fire, which regulates chemical action. Although the color is excellent, the crystals do not exceed one-twenty-fifth to one-fiftieth of an inch in diameter.

In *Nature*, vol. xxi, January 1, 1880, p. 203, Mr. MacTear, of the St. Rollo Works, Glasgow, published some investigations, by which, he claimed, he had produced artificial diamonds. Prof. N. S. Maskelyne proved this claim to be unfounded, as has been the case with other investigators. In 1880, Mr. J. Ballantine Hannay read before the Royal Society a paper in which he claimed to have successfully produced artificial diamonds, after eighty dangerous experiments. He had obtained the results, he said, by tightly sealing steel and iron tubes or coils, about four inches thick (some of which were made by boring out a solid block of iron), containing ten per cent. bone-oil and ninety per cent. paraffine spirit.* After subjecting these tubes to intense heat, for some hours, he produced fourteen milligrammes of residue, part of which he called diamond. The substance exhibited before the Society was undoubtedly diamond, being pronounced such by Profs. Maskelyne, Roscoe, Stokes and others; but none of it can be seen today in the British Museum cabinet, and as the specimens were of a fragmentary character, and not crystals, it is believed by many that, although they were diamonds, they were never made by Mr. Hannay.

PARIS EXPOSITION.

Fifty-five nations were represented at the Paris Exposition, and nearly every one of these had a governmental exhibit of the minerals of its country, besides in many cases collective exhibits of private collectors. Some of these exhibits were very remarkable, and had they been assembled in one building, as was the machinery in Machinery Hall, the mineralogical and metallurgical and precious stones exhibits would have been impressive ones. As it was, they were scattered over such immense distances that important ones were often overlooked.

* [A part of the charge was an alkali metal.—Ed.]

Class 41, which included minerals, or, in other words, the products of mining and the materials obtained therefrom, contained over 1,800 distinct exhibits. A collection of gold shown in this class by a French engineer, in the French Section, was perhaps the finest ever formed. It contained many remarkable specimens of gold from California; a wire of gold, six inches long, from Colorado; gold amalgam, nuggets and gold-dust. The 300 specimens represented almost every gold-producing country in the world, and the collection was the result of over thirty years' work.

In the centre of the French Jewelry Section, Class 37, was exhibited the Imperial or Victoria diamond, already described; at one of the four central corners, by Bapst & Falize, the historic Sancy diamond, weighing forty-one carats; opposite a necklace composed of pink, blue, yellow, brown, black and other colored diamonds. This section contained an immense number of fine and curious diamonds, rubies, emeralds and other precious stones, as well as several interesting lapidary exhibits, and nearly fifty exhibits of imitation stones of all kinds, imitation pearls, etc. A carved diamond turtle, a fly, and some curiously drilled diamonds were of more than ordinary interest.

In Class 18, Section of Decorative Arts, were some fine chandeliers of rock crystal, valued at $7,000 each; pedestals covered with slabs of *agate amethyst* from Lorraine, valued at over $2,000 a pair; rock-crystal spheres (not perfect however) up to six and one-half inches in diameter, and other magnificent examples of lapidarian work in agate, jasper, rhodonite and jade.

From the Pyrenees and from Belgium, magnificent collections of finely colored marbles were shown.

The Russian exhibit contained a case of nephrite and graphite, exposed by M. Alibert, similar to the collections shown at the Expositions of 1867 and 1878, which were presented by M. Alibert to the École des Mines, the Musée Naturel and the Conservatoire des Arts et Metiers. Jade was formerly obtained by M. Alibert in his graphite mines in Siberia, discovered in 1847 at Botovgal in the Sian Mountains, near the Chinese frontier. One mass of jade

from these mines weighs 1,300 pounds, another 1,100, and several of the specimens in the case weighed several hundred pounds each.

Of even more interest were the polished, transparent sections of boulders of jade, sawed by M. Alibert from blocks found by himself; these were beautifully polished on both sides, were less than one-eighth inch in thickness, and some measured 3 feet in length and over 18 inches in width, forming beautiful panes for windows having a delicate shading and a brilliancy not to be obtained in any other material. With this was a large series of graphite, curiously carved into ornaments, to show the perfect homogeneity and fine grain of the graphite from his mines.

The collection of Mr. Woerfel contained a large number of the table tops, mantels, vases and other ornaments of malachite, lapis-lazuli, rhodonite, labrador spar, and other stones characteristically Russian, which have been used extensively in that country in the decoration of churches and palaces, and have been frequently made use of as imperial gifts by the Czar, as the royal palaces throughout Europe will testify.

From the Ural Mountains came an exhibit of a magnificent series of blue, white and sherry-colored topaz crystals, some of the largest of which weighed one pound, and some smaller ones, several inches in length, were absolutely transparent; a doubly terminated crystal of beryl that weighed one pound eight ounces, but was not entirely free from internal fractures; small crystals of alexandrite; some magnificent purple amethysts, unrivalled for depth and richness of color; *chrome tourmaline* in crystals, from one to three inches in length, and other varieties of well-known Russian minerals.

In the Hungarian Section was a very interesting case of opals, and also opal in the trachyte matrix, from the famous Hungarian mines at Czernowitza, which have been worked for over 300 years.

In the Roumanian Section was exhibited a very interesting series of ambers, strikingly like those from Catania,

Sicily, in form and in color; the different colors shown were light yellow, dark yellow, cloudy white, opaque white, black, brown, bluish-green, dark opalescent blue, opaque red, of which Prince Bibesco loaned one of the finest known necklaces. This amber was all found in the department of Buzeo and in these places: Bisca-rusilei, Bisca-Chisjdului, Coltzia, Valea-boului and Bodila. The Roumanian amber is exceedingly rare and is very highly valued.

At the Exposition, there were three exhibits at which the branches of cutting and polishing were carried on. At the Holland pavilion, the display made by Boas Frères, of Amsterdam, had a number of polishing wheels, the motive-power of which was steam, as well as a machine reconstructed, showing the manner in which man-power was utilized during the eighteenth century. With this exhibit there was a large series, illustrating the various forms of cutting the brilliant, rose and table, as well as all the forms of rough diamonds, such as cleavages, splints, those for glass-cutting, and shaped for specially adapted tools.

Two Belgians exhibited diamonds—one perfect yellow octahedral diamond, weighing 300 carats; a diamond cross, cut from a single stone (which is not unique, as claimed by the exhibitor, for such a stone was contained in the Hope Collection and was illustrated in the Hope Catalogue of 1839); some fanciful and curiously-cut brilliants; a small sword cut out of three diamonds, and the name of the exhibitor in table diamonds, seventeen of which were nearly an inch in length.

In the main aisle, Coutermans, of Antwerp, had an exhibit with the polishing wheels, an exhibit of the diamonds in the altered kimberlite, and a black diamond, weighing thirty carats, which it was reported had been purchased by the Shah, but of which in reality he only inquired the price.

Greece made a magnificent display from the famous mines at Laurium, which were worked before the beginning of the Christian era, as is proved beyond doubt by the fact that, in the collection in the Assyrian Gallery, in the Louvre, the writer saw necklaces made of beads of gold and

carnelian, and also, to his surprise, of the blue and white-veined beads of so-called calamine (Smithsonite), from Laurium. Masses of this mineral were exhibited that must have weighed at least a ton each, and in the general exhibit were magnificent botryoidal specimens, from this locality, of the blue, green and yellow calamine, which rivalled anything found elsewhere.

In the Persian Section were shown masses of lapis-lazuli, weighing several pounds each, and a large series of cut and engraved Persian torquoises.

In the Madagascar Pavilion was exhibited a series of gravels containing sapphire, zircon and tourmaline.

A collection of precious and ornamental stones of North America, as well as a collection of foreign precious stones, was displayed by Messrs. Tiffany & Co., in the American Section. The former collection was contained in a circular case nine feet in diameter, on a platform erected at the intersection of the four aisles of the American Section. This collection was formed for the purpose of illustrating the occurrences of the precious and ornamental stones in North America, and contained many of the finest examples that have been found, some unique, others entirely new. This collection was the result of purchase, completed by generous loans from some of our prominent mineralogists, and was an object of interest to the many visitors of the Exposition.

One of the features of the jewelry exhibit was the utilization of American stones and pearls in jewelry, notably tourmalines, beryls (yellow, green and blue), rock crystals for vials and boxes, and pearls from the unios in a large variety of objects--the motive, as well as the materials employed, being American in character.

Among the more important things in this collection were some small diamonds from California; a series of the original crystals of sapphires, collected by Col. C. W. Jenks when he opened the Jenks Mine in Franklin, Macon County, N. C.—among them the first sapphire found in the United States; a ruby of fair color, some American crystals and cut topaz from Cheyenne Mountain, Col.; one of the largest

crystals of emerald from Alexander County, N. C., loaned by Mr. Bement; the cut aquamarine, weighing $133\frac{25}{32}$ carats, from Stoneham, Me.; thirteen cut aquamarines from Mt. Antero, Col., found at an altitude of 14,000 feet above the sea; a number of cut spessartite garnets, one of which weighed $96\frac{1}{16}$ carats, from Amelia Court House, Va.; a series of colored tourmalines, both cut and crystal form, from Mt. Mica and from Auburn Me.; a collection of pearls and the shells in which they are found on the shores and in the rivers and brooks of North America.

Some notable things in the Tiffany foreign collection were a series of twenty-four fancy colored sapphires, weighing from two to twenty carats, and showing every color of the spectrum, some fine alexandrites, chrysoberyls, and zircons from Ceylon; crystals and cut euclase from Brazil and Siberia, and a number of interesting precious and ornamental stones.

The Brazilian Commission exhibited a very interesting collection of the precious stones of Brazil, especially the diamond and its associations, but not such fine examples as those shown at our Centennial Exposition. Many of the fine specimens in this exhibit were loaned by European collectors and dealers. Among those of chief interest were a dish of yellow topaz crystals, several of which are over two inches in length and one inch in diameter; magnificent crystals of green tourmaline, from two and a half to four inches long; fragments of crystals of amethyst, two and three inches in diameter; diamond crystals, from less than the size of a pin-head up to six carats. There was also a collection of minerals associated with the diamond in Brazil, consisting of rutile, zircon, anatase, lazulite, and a set in miniature of the implements and bowls used in washing and in digging and working the river gravels. This entire case is the production of the province of Minas. Of special interest are the "Sables Diamantifères," as the conglomerate rock containing the diamond is called, and also the masses of klaprothine, identical with the lazulite of Georgia, and the series of minerals of the gravels which were identified by Prof. Gorceix, of the School

of Mines, at Oura Preta, among which were pyrope, cyanite, pyrite, fibrolite, xenotime, anatase, hematite, limonite, tourmaline, monazite, baierite (titanic iron) and itacolumite rock. These are especially interesting since they have all been found in North Carolina and Georgia. The Vicountess de Cavalacantie exhibited a case of jewels from the province of Minas, among which were some fine amethysts, topazes, aquamarines, citrines and five beautiful examples of the chrysoberyl or chrysolite jewelry worn and made in the latter part of the eighteenth century.

Among a remarkable series of ornaments made and worn by the Botocudo Indians of Brazil were some made of materials of marked mineralogical interest. The most notable were lip ornaments, one a rich Amazon-green feldspar in the form of a disk, 2½ inches in diameter and about 1 inch thick, with projecting shoulders for retaining the ornament in the lip. The great breadth of this would suggest difficulty in the use of a pipe; but Dr. Ladislaus Netto, Director of the National Museum, Rio de Janeiro, exhibited a pipe used by the Indians, adapted to overcome this difficulty. The stem was flat and over two inches in diameter and quite thin, so that it could be laid on the projecting lip ornament and easily held in the mouth. Another lip ornament was 3 inches long and 1½ wide; another an oval disk, 3½ inches long and 1 inch thick, of beryl; a flat, sole-like fish, 2 inches long and 1 inch wide, made of a material said to be jade; a circular shaft of rock crystal, five inches long, with two projecting ends; two spear-heads, three and four inches long, and some ear ornaments, all made of transparent rock crystal.

In the Bolivian Pavilion was also a series of specimens of lapis-lazuli from the Andes, to which were given four distinct names, *i. e.*, Lapis agatado, lapis-lazuli, lapis maclado, lapis laminosa. The most important exhibit was in the United Diamond Mines Building, in which every process connected with the mining and cutting of the diamond could be seen under one roof.

First the large sacks of earth, of which 1,000 were washed at the Exposition, were thrown onto a screen which

sifted the material into a large washing-pan, or "compound" as it is called, about fifteen feet in diameter. In this compound all the soft mud, light particles of shale, kimberlite, quartz, calcite and other minerals, whose specific gravity is less than that of the diamond, were floated out, and in the centre the diamond, garnet, pyroxene and heavier minerals were concentrated. These concentrates were then carefully sorted, the garnets and the diamonds being the only ones of value.

In connection with this exhibit were shown models, or rather reproductions, made of earth, and small models, exact duplicates of the machinery and the tunnel systems used at the mines.

The De Beers Consolidated Mines exhibited, in a large central case, 5,138 carats of rough diamonds. This case was securely covered with an iron cage, like a parrot cage in form, exposed by the maker of the cage in which the Kohinoor diamond was exhibited at the London Exposition of 1851. In this exhibit was a cut diamond, the largest brilliant in the world, weighing 228½ carats, which in the rough had weighed over 400 carats; one large octahedral crystal weighing 306 carats, and a collection of 983 carats of fancy-colored crystals of white, mauve, pink, orange, yellow, brown and black; also, a large number of distorted and curious crystals. The Belfontein Mine exhibited 11,227 carats of rough diamonds, and the Griqua Land West Diamond Mining Company a parcel of 45,003 carats.

At the opening of the Exposition the diamonds were valued at twenty-two shillings a carat, and at its close at thirty-eight shillings; so great has been the advance in the price of rough diamonds. One thousand sacks of diamond earth were washed at the Exposition, and the average amount of diamond found was one and one-half carat to a load of earth.

In connection with this exhibit was the cutting of diamonds, carried on by M. Roulina, who reintroduced diamond-cutting in France, and is one of the few men abroad who has utilized a machine for the process. This machine, however, is very primitive in comparison with the

more perfect one invented fifteen years ago in the United States and in use here since. There were also diamond-piercing machines in operation; these required from twenty to thirty days to pierce a diamond of about two millimetres in thickness, the drills revolving at the rate of 14,000 revolutions a minute.

Not without interest was a diamond which had been a beautiful white stone of about nine carats, but which was shattered into fragments while undergoing the polishing process on the wheel.

ON PHOSPHORESCENT DIAMONDS.

On November 4th, I was enabled to make an experiment, through the courtesy of Dr. E. Mascart, membre de l'Institut, Director of the Central Observatory of Paris, and Prof. B. Abdank, electrician, member of the jury, who arranged a dark room, in which a collection of over one hundred and fifty diamonds was placed. In one side of the wall was inserted a lens, and outside the room was suspended a new alternating arc lamp of the Thomson-Houston system. The lens, which served the purpose of concentrating the light, was covered with a violet-colored glass, so that only the ultra-violet rays were thrown on the diamonds, which numbered over 150 stones. Among these were several old Indian, Brazilian and Cape stones, and from the South Africa River diggings. Of the entire collection, only three diamonds were phosphorescent. One, a Brazilian stone of one and five-eighths carats, possessed this quality in a remarkable degree; an old Brazilian stone of three carats also showed the same property; all the others assumed a beautiful violet tint. The two stones whose phosphorescence was most marked were perfectly transparent white stones, one with a bluish tinge; they assumed the milky white color of the variety peculiar to the Bagagom mines of Minas Geraes, of which only a few are annually found. The phosphorescence exhibited by these stones was extremely beautiful, it remained visible when a metallic cap was put over the lens, gradually losing its intensity, however, for fifteen minutes after the exposure. All the other stones

collected were invisible in the dark. Pure white light was also used, resulting in a less beautiful experiment, though the phosphorescence was quite as apparent.

This test fully demonstrated the fact that some diamonds, though not all, possess the power of absorbing light, and emitting it in the dark; and in those possessing it, it is found in different degrees of intensity.

An experiment was also made to test perfection of cutting. Light from a common arc lamp was concentrated on the table of stone, from the facets of which spectra were reflected on the wall, the regularity of which depended upon the perfection of the cutting.

Dr. Crookes says: "Next to the diamond, alumina in the form of ruby is, perhaps, the most strikingly phosphorescent stone he had examined. It glows with a rich full red, and a remarkable feature is that it is of little consequence what degree of color the earth or stone possesses naturally, the color of the phosphorescence is nearly the same in all cases—chemically precipitated amorphous alumina, rubies of a pale reddish yellow and gems of the prized pigeon's-blood color glowing alike in the vacuum, thus corroborating E. Becquerel's results on the action of light on alumina and its compounds in the phosphorescope. The appearance of the alumina glow in the spectroscope is remarkable. There is a faint, continuous spectrum ending in the red somewhere near the line B; then a black space, and next an intensely brilliant and sharp red line, to which nearly the whole of the intensity of the colored glow is due, this suggesting that the colors in corundum gems may only be a change in the alumina, and not a definite coloring matter."

Considerable attention has been given to the alleged power of diamonds to emit light in absolute darkness. Dr. William Crookes, in his experiments on the phosphorescence of diamonds of various colors, found that those glowing pale blue had the longest residual glow. Next came the yellow. He was unable to detect any residual glow in diamonds of a reddish color. A large diamond of greenish hue, very phosphorescent, shone almost as brightly in the phosphorescope as out of it.

To the numerous allusions that have been made in the press to the exhibit of artificial stones at the Paris Exposition, is probably due the popular error that confounds the word "artificial" with the word "imitation." Not a single artificial diamond, ruby or sapphire was shown; but there were some hundreds of exhibits of imitation stones from France, Austria, Hungary and Germany. The term "artificial" can be correctly applied only to a gem that is artificially made; whereas, the term "imitation" covers all glass and such other productions.

COAL-WASTE COMMISSION.

The Commonwealth of Pennsylvania has appointed a commission, consisting of J. H. Price, E. B. Coxe and P. W. Sheafer, to consider the question of coal waste in the state of Pennsylvania. This commission has divided the subject into three heads, viz: Geological and statistical waste; Waste of producing and marketing, and Utilization of coal-waste. The circular-letter containing the above divisions and subdivisions has been addressed by the commissioners, together with a special letter, to a number of individuals and editors, in order to obtain on the subject every possible information. This action recalls the committee which was appointed by the American Institute of Mining Engineers, at its first meeting, held in Wilkesbarre, May 16, 1871, when R. P. Rothwell read a paper on "The Waste in Coal Mining," and, "at the conclusion of the discussion of Mr. Rothwell's paper, a committee was appointed, consisting of Messrs. E. B. Coxe, Thos. S. McNair, Daniel Hoffman, E. Gaujot, R. P. Rothwell and Wm. B. Hicks, to consider and report upon waste in coal mining."

Although Mr. Rothwell had opened his remarks by characterizing the inquiry as a subject "of the greatest possible importance to the industries we represent," and added, "it is a fact, which many of you can certify to, that we are wasting *fully one-half of all the coal in the veins* we are now working, and there are cases which might be mentioned where this proportion, immense as it is, has been greatly

exceeded;" with the exception of a preliminary report—(very preliminary)—sketching the method of going to work, at the Bethlehem meeting, in August of the same year, this committee never reported, though, from time to time, the subject came up; as in J. W. Harden's paper on the wasting of coals at the mines, in the Boston meeting of February 18, 1873, in the discussion of J. Price Wetherill's paper on "Anthracite Coal Mining in Schuylkill County," at the Philadelphia meeting of October, 1876, and, incidentally, in a paper by W. P. Shinn, on "The Advance of Mining and Metallurgical Art," at the Philadelphia annual meeting of February, 1881.

In fact, it got to be one of the perennial jokes of the A.I.M.E meetings to allude to the report of the Committee on Coal Waste.

The reason for the dilatoriness of this committee was never generally understood. Subsequently, in 1881, a report on coal waste (A2) was made by Franklin Platt, from the geological survey of the state; and a chapter was devoted to the subject by Dr. H. M. Chance, in report AC. (1883), under the general title of coal mining.

These, and several other treatises on the subject, have repeatedly called the attention of engineers to the reckless misuse of the bounties of Nature, but without the result of extinguishing the evil.

The results of the commission will be looked for with much interest, both by scientific men and consumers of coal.

The ability of the commissioners appointed is unquestioned. F.

THE PROCESSES OF STEAM IN ITS DEVELOPMENT OF POWER BY MEANS OF A STEAM ENGINE.

BY CHIEF ENGINEER ISHERWOOD, U.S.N.

[*A Lecture delivered before the Sibley College of the Cornell University, Ithaca, N. Y., December 13, 1889.*]

At the present stage of steam engineering, the most important research as regards the use of steam in steam engines to produce continuous mechanical power, is the investigation of the various processes of the steam from leaving the boiler to arriving in the condenser. No attempt, to my knowledge, has been made up to the present hour to ascertain the kind and value of these processes, to show the great influence they exercise on the potential and economic effect of the engine, and to determine in what direction and to what extent they affect the possibility of improvement. A knowledge of these processes will prevent a waste of effort in wrong directions, will prevent attempts to overcome imaginary difficulties while ignoring real ones, and will guide unerringly to all that is possible to be obtained, having regard to the limitations imposed by Nature and to which art must accommodate its labors if success is to follow them. Steam engineering, like all branches of industry, has a two-fold aspect; it may be practised as an art, or it may be studied as a science, but its perfection requires it to be considered as an art elucidated by science and guided by the latter as far as practical and economic conditions will permit.

As an art, the designing and constructing of steam engines has been by a purely tentative process—very long, very uncertain and very costly—brought to a high level: experience, with alternating success and failure, has been the blind guide under which the constructive instincts of a succession of engineers have blundered along until the successes of the present day have been achieved. But although science has contributed nothing to the growth of the steam

engine, it alone can explain its methods, point out the direction in which something more may be obtained, show the causes by which its operations are performed, demonstrate the limits to its progress, destroy false hopes, and give the ability to know when the utmost possible has been attained. It is retrospective and prospective; it not only illumines the path already passed over, like the stern-lights of an advancing vessel, but, like the bow-lights of the same vessel, it can show the way ahead with certainty and safety.

There is a very sufficient reason why science contributed nothing to the improvement, or rather to the proper understanding of the steam engine. The requisite science applicable for that purpose did not exist until quite recently. Not until the experiments of Regnault and the discovery and correlation of the facts of thermodynamics into a consistent system, could a true theory of the steam engine be formed; and until these researches were complete all advances had to be made tentatively by groping in the dark. There had, besides, to be made many and accurate experiments on engines of different types, dimensions and regimen, the results of which were to be confirmatory or subversive of the theory. Thus, the steam engine furnishes the best and surest foundation for thermodynamics up to the present hour; and it furnishes, also, the clearest and completest illustrations for that science. The proper methods of experimenting and of interpreting the results of the experiments had also to be devised. In physical investigations, even of the simplest kind, the deductions of science cannot be accepted with confidence until they are verified by experiment; and still less could such deductions be received without the fullest experimental evidence in so complicated a case as that of the steam engine. Without the results of Regnault's experiments on steam, and without the principles and data of thermodynamics, the performance of the steam engine would still remain the mystery it previously was.

The steam engine has been termed an elastic-pressure engine, and a heat engine, neither of which terms is philosophically correct, nor gives a clear apprehension of

the real facts of the case. The force which urges the piston of a steam engine is not an elastic force of the nature of the elasticity of a spring or of caoutchouc. It is, on the contrary, a concussive force acting by the impact of distinct molecules of steam, as a volley of bullets fired from a mitrailleuse acts against a resisting surface. The steam molecules are material bullets of infinitesimal dimensions moving with high velocities and endowed, consequently, with *vis viva* which must remain in them until imparted to other matter. Nor is the steam engine a heat engine in the popular sense of the word heat, for there is no such thing as heat as a distinct entity, and the term has meaning—apart from organic sensation—only when used as a synonym for molecular *vis viva*. The steam engine, considered in the concrete, is a mechanism for converting molecular *vis viva* into mass *vis viva*, the molecular *vis viva* being composed of the product of the number of steam molecules in use, the mass of each, and the square of their mean velocity. The mass *vis viva* is the useful or commercial load or resistance to be overcome, and is always a more or less small fraction of the molecular *vis viva*, the remaining portion of the latter being expended in the processes which the steam undergoes from leaving the boiler to entering the condenser, and imparted to the condensing water, or, if the engine be a non-condensing one, escaping unused with the exhaust steam into the atmosphere. The greater the fraction which the mass *vis viva* is of the molecular *vis viva*, in the case of the steam engine, the greater is the economy with which the mass *vis viva* is obtained or the commercial work done; and this fraction is affected so largely by the mechanism itself and by the material of its construction, apart from the manner in which the steam is used, that no theory of the steam engine can be complete which does not include these effects due purely to the mechanism and its matter.

By considering all the effects produced by steam in its passage through a steam engine as simply dynamical, resulting from a mechanical cause and identical with those produced by bodies in motion striking other bodies, a clear

and intelligible idea is obtained of the operations, which is impossible by considering them as the effects of heat or of elasticity. As particular cases of *vis viva* these effects are visible and tangible to the mind, because, when the masses are large enough, the effects are visible and tangible to the senses, and what is true in the one case is true in the other, the laws of mechanics as derived from the phenomena of sensible masses in motion being precisely the same as those of the insensible masses called molecules in motion: the magnitude of the mass does not affect the laws. Inferences can be drawn and results calculated *à priori* when the case is simply one of *vis viva*, but when the effects are referred to heat or to elasticity, nothing definite is apprehended. The erroneous notions of the nature of heat which so long prevailed were due to a failure in perceiving these facts. Nevertheless, the terms "heat," "elasticity" and "pressure" are so thoroughly interwoven in the units of measure, in the formulæ, in the literature, and in the reasonings of engineering science, that they will, probably, never be eradicated. They are brief and useful, and when their true import is known there are no objections to their retention.

One of the most important facts discovered by the experiments of Regnault, is the increase in the latent heat of steam as its pressure becomes lower. If steam be expanded or lessened in pressure without doing external work, the difference of its temperature before and after expansion would tend to superheat it at the lower pressure, but as the latent heat increases with the decreased pressure, the tendency of this increase is to absorb heat, so that the condition of the steam after the free expansion—whether superheated or saturated—would be determined by the relative quantities of heat thus set free or absorbed. Now, the absorption of heat by the increase of the latent heat is greater than the heat liberated by the difference of temperature, so that steam expanding without doing external work would remain in the saturated state, a contrary result to the free expansion of an ideal gas, and, moreover, would undergo a liquefaction of a portion to furnish the heat

required to maintain the remainder in the state of steam. Saturated steam, therefore, will partially liquefy by expansion *per se*, and to an extent determined by the excess of the increase in its latent heat over the heat due to the difference of its temperatures before and after expansion. If, however, the expanding steam does external work, there will be transmuted into the work of expansion a portion of the heat of the steam, and the quantity of heat thus transmuted is much more than sufficient alone to keep the steam in the saturated state, consequently, the whole of the difference between the latent heats due to the pressures before and after expansion will have to be furnished by the liquefaction of a sufficient portion of the steam to liberate the heat required to maintain the rest of the steam in the state of steam. Expanding steam, therefore, when doing external work, undergoes a partial liquefaction additional to the liquefaction due to this work, and in proportion to the difference between its latent heats at its pressures before and after its expansion. This liquefaction may be called the liquefaction due to the expansion *per se*.

The latent heat of a pound weight of saturated steam is the measure of its *vis viva* in units of heat. The molecules of the steam must be endowed with that quantity of *vis viva* to remain in the form of steam. Now, as more *vis viva* or heat, (exclusive of the heat transmuted into the external work of expansion,) is required to keep the molecules of expanded steam in the state of steam under lower, than under higher pressures, the quantity of *vis viva* in the expanded steam will be insufficient to maintain the whole of it in the form of steam, and the excess must lose its *vis viva* and liquefy. This excess admits of calculation. There must liquefy such a fraction of the weight of the expanding steam as the difference between the latent heats of the steam before and after expansion is of the latent heat before expansion. This quantity of liquefaction takes place in all cases of expanding steam when the steam remains saturated during the expansion. The fraction in pounds of the weight of the expanding steam thus liquefied by what may be called its expansion *per se*—a liquefaction additional

to the liquefaction due to the transmutation of part of the heat of the expanding steam into the external work of the expansion—multiplied by the latent heat of the steam before expansion, gives the number of units of heat transmuted into the additional *vis viva* required. The quantity of heat thus transmuted depends obviously on the degree to which the steam is expanded, and the pressure from which it is expanded, but under the average conditions of practical steam engines, it will be found a very serious quantity exerting a marked influence on the economy with which the power is developed.

The following question must now be answered: In what state is the water of liquefaction due to the expansion of steam *per se* to be found, and how is this liquefaction distributed among the molecules of the steam?

Steam is composed of hydrogen and oxygen, and its simplest conceivable molecule would contain two atoms of the former and one atom of the latter; but the real steam molecule is doubtless a group of such simple molecules linked together in an unknown manner and acting as a unit. The molecule is acted on by a certain force, which maintains it at a determinate speed, its *vis viva* being represented by the product of its mass into the square of its speed. If, now, (say) one-half the mass be detached, the impelling force remaining as before, the remaining half mass will move with increased speed and will have a corresponding increase of *vis viva*. This is what takes place with steam when it expands; every steam molecule undergoing partial liquefaction; that is, liquefaction of one or more of the simple molecules composing it, in order that the remaining simple molecules of the steam molecule may receive the necessary increase of *vis viva* for maintaining them in the form of steam. Always, when saturated steam expands, with or without doing external work, this molecular liquefaction occurs, and in proportion to the measure of the expansion. The more the steam is expanded, the more of the simple molecules composing the original steam molecules will be liquefied. Expanded steam is thus wet steam, and wetter in proportion as it is more expanded. Further,

it is the only kind of wet steam. This water of liquefaction being in infinitesimal drops or masses, will long remain suspended mechanically in the remaining steam, rendering the latter opaque and giving it the appearance of haze, mist, fog or cloud. With sufficient time, however, these inconceivably small drops of water would precipitate by gravity upon the surfaces beneath them, but their descent through the resisting medium of the steam would be so exceedingly slow that in the case of the steam engine this precipitation never occurs for want of time, and the liquefied simple molecules are swept through the engine without sensible deposition. Unexpanded steam is always transparent; it is an invisible vapor; nor is its invisibility affected by mere mixture with it of additional water of the same temperature, as in the case of boilers priming or foaming. The primed or foamed over-water constitutes a distinct mass, side by side with the steam, but not intimately mingled with it, and separable almost instantly by gravity. The steam itself in this case is not wet.

Until the constitution of matter and the forces which produce the movements of its atoms are exactly known, the precise conditions of no physical problem can be given, but even with vague generalizations, confirmed by experiment, some approach can be made to a decision. Above all, in order to understand the action of any force, we must be able to form material conceptions of its operation, without which tangibility we cannot have any real grasp of the subject.

There remains a second cause of liquefaction of expanding steam in a steam engine, namely, the external or commercial work done by that steam, including overcoming the back pressure against the piston; this liquefaction is directly proportional to the heat transmuted into the work done by the expanding steam, counting that work down to the zero of pressure. In other words, the foregoing deals with the consumption of heat, or of *vis viva*, connected with the transference of heat or *vis viva* from some of the molecules of the expanding steam to the remainder in order to maintain the equilibrium of the latter after the expan-

sion, the action being wholly internal to the steam, and neither affecting nor being affected by the external work done by the expanding steam; but when steam expands against an external resistance it does external work, undergoing thereby a corresponding loss of heat, and suffering an equivalent liquefaction.

The steam molecules strike the piston with a *vis viva* represented by the product of their mass into the square of their mean velocity. The loaded piston being free to move, yields to the impact, and in moving takes up a portion of the *vis viva* of the striking molecules, which of course lose exactly that portion, having transferred it to the piston. As regards the steam in the cylinder previous to the commencement of its expansion, this loss of *vis viva* is instantly restored from the boiler (at the expense of the fuel), so that no liquefaction of steam takes place in the cylinder from this cause previous to its expansion, the loss of heat being transferred from the cylinder steam to the boiler steam, which continually receives fresh accessions of heat from the burning fuel. There is a real liquefaction of steam in the boiler corresponding to the heat equivalent of the work done in the cylinder previous to the expansion of the steam, but the water of this liquefaction is instantly revaporized in the boiler by the fuel. But when the steam commences to expand, after the closing of the cut-off valve of the cylinder, it is separated from the boiler steam, and can no longer receive accessions of *vis viva* or heat therefrom; consequently, all the heat transmuted into the external work of the expanding steam has then to be taken from that steam itself, which undergoes a resulting liquefaction corresponding to the heat or *vis viva* transmuted into this work. When expanding steam does external work, it not only partially liquefies correspondingly to that work, but that liquefaction is accompanied by the additional liquefaction due to the increase of the latent heat. The greater the expansion the greater the liquefaction from both causes. The temperature of expanding steam, when that steam remains in the saturated state, as it does when performing work, decreases with each increase of expan-

sion; and, when it falls to something less than 32°F., it changes into water; the liquefaction has become total, and that is the physical limit of the expansion of saturated steam.

The quantity of heat or molecular *vis viva* transmuted by expanding steam into the external work developed by the expansion can be calculated. Accepting 789¼ foot-pounds of work as the mechanical equivalent of one Fahrenheit unit of heat, the division of the number of foot-pounds of work done by the expanding steam, by 789¼, gives the number of Fahrenheit units transmuted into that work, and if this quotient be divided by the mean latent heat of the expanding steam, the quotient will give the number of pounds weight of steam liquefied to furnish this quantity of heat.

The number of foot-pounds of work done by the expanding steam must be obtained experimentally (by an indicator in the case of the steam engine), as the curve of the expanding pressures cannot possibly be calculated, even under abstract conditions, much less under the practical conditions of a steam engine.

From the moment the steam begins to expand there are simultaneously a continuous molecular liquefaction of a portion of it, and a continuous diminution of its temperature, both of which tend to lessen its pressure. There is, also, during the expansion portion of the stroke of the piston, a continuous evaporation of steam from the water of liquefaction due to the heat interaction of the metal of the cylinder with the steam, and this evaporation tends to continuously increase the pressure. Now, if the lessening of the pressure by the molecular liquefactions were exactly compensated by the increasing of the pressure by the steam of the revaporized water of liquefaction due to the interaction of the metal of the cylinder, the curve of the pressures of the expanding steam would exactly follow the Mariotte law. Again, the molecular liquefactions and the decrease of temperature are caused wholly by the expansion of the steam, and the interaction of the metal of the cylinder is likewise caused almost wholly by

the expansion of the steam, so that if all the water of liquefaction due to the interaction of the metal were revaporized during the expansion portion of the stroke of the piston, which, in general, is the fact, and if all the molecular liquefactions took place during the same portion of the stroke, the two should counterbalance each other, for they stand in the relation of cause and effect. But all the molecular liquefactions do not take place during the expansion portion of the stroke of the piston, some liquefaction takes place during the exhaust stroke, caused by the expansive expulsion of the steam from the cylinder after the opening of the exhaust port, and some liquefaction takes place due to the transportation of the steam from the boiler to the cylinder. In general, the steam evaporated from the water of liquefaction due to the heat interaction of the metal during the expansion portion of the stroke, exceeds by a very variable fraction (sometimes very small and sometimes quite large, according to the regimen of the steam), the molecular liquefactions during the same portion of the stroke, so that the pressures given on the indicator diagram by the expanding steam rise higher and higher above the pressures due to the Mariotte law, as the piston advances, until at the end of its stroke the difference is the greatest. When the steam is used without expansion in medium-sized and large cylinders, it experiences but very little liquefaction.

The liquefaction due to the transmutation of the heat of part of the expanding steam into the work of expansion, is effected upon every molecule of that steam, and the resulting water, in infinitesimal drops or flakes, continues suspended in the remaining steam, giving it the appearance of haze, mist, fog or cloud, the opacity being the greater as the work of expansion is greater, whereas non-expanded steam, though doing work, is perfectly transparent. This form of liquefaction of the steam is just the same as previously described for the similar liquefaction due to the increasing latent heat that accompanies expansion. But there is this difference that, in the case of the increasing latent heats, the liquefactions were caused by the transference of *vis viva*

from one portion of the steam molecules to another portion, while in the case of expansion doing work the liquefaction is caused by the transmutation of molecular *vis viva* into the mass *vis viva* represented by the load on the piston. But in both cases the final effect was the same, namely, the waters of these liquefactions were in the form of excessively comminuted spray as intimately mixed with the steam as its own molecules were intermingled. These extremely light particles of spray can not for want of time, and because of the resistance of the steam medium, precipitate by gravity upon the cylinder surfaces beneath, they, therefore, remain suspended in the steam and are swept out with it during the exhaust. Of course, the bulk of these waters of liquefaction was added to the bulk of the steam which thus appeared by that much greater than it really was. The expanded steam, as has been shown, is *wet* steam, and *wetter* the more expansively it is used.

The two liquefactions that have been described are inseparable from the use of saturated steam expansively.

Thus far there has only been considered the liquefactions of steam which take place in the cylinder of a steam engine using steam expansively, independently of any liquefaction that may be effected by the alternate heating and cooling of the metal of the cylinder during a double stroke of its piston, caused by the expansive use of the steam. This latter liquefaction must now be considered.

Taking first the case of an engine in which the steam is used without expansion, and, therefore, dry; and supposing the cylinder at the commencement of the stroke of its piston to have the temperature of the steam entering from the boiler, then, during the steam stroke of the piston, there will evidently be no liquefaction of steam. When the exhaust valve opens, the steam is expelled by its own expansion from the cylinder into the condenser, where it is annihilated. During this expansive expulsion of the exhaust steam it does, owing to its expansion, molecular work, and undergoes corresponding liquefaction. As the exhaust steam does no mass work during its passage into the condenser, because it is there annihilated, it will suffer only

the slight fall of temperature due to the molecular work of its expansion, and will therefore have but a trifling effect in cooling the metal of the cylinder. Hence, in the case of using steam without expansion, the interaction of the metal of the cylinder with the heat of the steam is very small, the temperature of the metal of the cylinder varying but little during a double stroke of its piston, from the temperature normal to the pressure of the entering steam. When the steam is used without expansion, the interaction of the metal of the cylinder with the heat of the steam is, therefore, very little during a double stroke of the piston.

Whatever temperature the metal of the cylinder loses during a double stroke of its piston, is restored to that metal by the steam entering from the boiler, which steam consequently undergoes a liquefaction corresponding to the quantity of heat thus transferred from it to the metal. The water of this liquefaction is uniformly deposited like a dew upon the inner surfaces of the cylinder and remains there to the end of the stroke of its piston, if the steam be used without expansion. When the exhaust valve opens and the pressure of the exhaust steam is lessened to nearly that of the space into which it is discharged, the deposited water of liquefaction is rapidly boiled off or revaporized under the lessened pressure, partly by its own contained heat, but principally by the heat of the metal on which it rests, taking from the latter an equivalent quantity of heat and reducing its temperature accordingly. The heat of vaporization of this water of liquefaction passes out of the cylinder with the exhaust steam and is lost.

The absolute dimensions of the cylinder are of importance in this relation. The larger those dimensions the less will be the liquefactions due to the heat interaction of the metal and steam, in proportion to weight of steam used from the boiler. For example, if all the dimensions of a cylinder be doubled, its surface will be increased four times, but its capacity will be increased eight times. In this case the influence of the surface on the liquefaction will be halved, relatively to weight of steam used from the boiler.

The loss of heat by the metal of the cylinder in the case

of using the steam without expansion, is then of two kinds: (1) That of the heat abstracted from the metal and carried out of the cylinder by the exhaust steam, due to the slight cooling of that steam by its molecular work during its expansion into the condenser: and (2), that of the heat of vaporization of the water of liquefaction caused by the above abstraction of heat from the metal, having to be restored by the entering steam, which suffers in consequence a corresponding liquefaction.

When, however, the steam is used expansively, doing external work, the liquefactions of the steam in the cylinder rapidly increase as the measure of expansion increases. After the closing of the cut-off valve, the temperature of the metal of the cylinder being supposed to be then equal to that of the steam entering from the boiler, the pressure and temperature of the steam decrease continuously to the end of the stroke of the piston, and, as a consequence, the expanding steam continuously abstracts heat from the metal of the cylinder from the commencement to the end of the expansion. During the entire expansion the steam is in the saturated state, notwithstanding the fact that its temperatures at lower pressures are less than at higher ones, because the heat transmuted into the work of the expansion is greater than the heat due to the differences of temperature. Were the opposite of this the case; that is, were the heat transmuted into the work of the expansion less than the heat due to the difference of temperature for the expansion, the expanding steam would become superheated, and there could be no liquefaction resulting from the expansion. Such, indeed, is the fact in the case of steam at exceedingly high pressures and correspondingly high temperatures. There is a pressure—far above what can ever be employed in practice—at which inversion of these relations takes place, the heat equivalent of the work of expansion being then less than the heat due to difference of temperature, and superheating instead of liquefaction would, under that condition, be the result of using the steam expansively.

Returning to the expansion of steam under practical conditions. As the pressures and, consequently, the tempera-

tures of the steam fall with the expansion, the steam becoming wetter and wetter, too, the further the expansion is carried, having its heat interacting power with the metal continuously increased in proportion to its increasing wetness, the metal of the cylinder is continuously cooled, keeping pace with the lessening temperatures of the expanded steam, until when the end of the expansion, or end of the stroke of the piston is reached, the temperature of the metal and that of the steam at the end of the stroke of the piston are equal, if not to the entire depth of the metal, at least to a considerable part of that depth. Now, when the piston is at the end of its stroke, the metal of the cylinder has been reduced from the temperature of the steam entering from the boiler, which it had at the closing of the cut-off valve or commencement of the expansion, to the temperature of that steam after its expansion was completed. The exhaust valve now opens, and if the steam has not been expanded to the condenser pressure, a further expansion then takes place to nearly that pressure, and the heat of the revaporization of the water of liquefaction present in the cylinder at the end of the stroke of its piston, under this lessened pressure of the condenser, being chiefly abstracted from the metal of the cylinder, reduces the temperature of that metal to nearly the temperature of the condenser. The whole of the heat required to raise the temperature of the metal from the temperature of the condenser pressure to that of the entering steam, must be restored from the heat in the latter, which, of course, suffers a corresponding liquefaction in furnishing it. The whole of the water of this liquefaction is present in the cylinder when the cut-off valve closes, and has the temperature of the steam from which it was derived. From the closing of the cut-off valve it commences to revaporize, and continues to boil off during the succeeding expansion portion of the stroke of the piston, and during the return stroke while the exhaust-valve is open, if any remains not vaporized at the end of the expansion part of the stroke, the whole disappearing in vapor from the cylinder by the time the exhaust stroke is completed. There is no water in the

cylinder on the exhaust side of the piston when the latter reaches the end of its stroke; were this not the case, there would be an accumulation of water in the cylinder that would soon stop the engine.

The water of liquefaction in the cylinder is vaporized under the continuously lessening pressures and temperatures of the expanding steam, partly by its contained heat, but principally by the heat of the metal, and the steam from the portion thus vaporized during the expansion part of the stroke is utilized in pushing the piston. This utilization, however, is vastly less than what would be obtained from the same quantity of heat employed to vaporize water in the boiler were the resulting steam used in the cylinder. Except for this steam from the revaporized water of liquefaction in the cylinder, the pressure of the expanding steam on the piston, as shown by the indicator, would be greatly less; in fact, a very considerable portion of the expansion pressures in the cylinder is composed of this steam of revaporization, and is not due to the expansion of the steam of the pressure in the cylinder at the closing of the cut-off valve.

The practical curve of the expanding steam, as given by the indicator, is so complicated by this steam of revaporization, the proportion of which to the steam evaporated in the boiler varies so greatly with dimensions and type of engines and with the regimen of the steam as to render the various formulæ for calculating the pressures of expansion mere rubbish. No formula, rational or empirical, can possibly be devised that will reproduce the practical pressures. The only information which can be obtained in this matter is from the indicator, and each case is a special problem requiring a distinct experimental solution.

The portion of the steam re-evaporated during the exhaust stroke of the piston, if there be any such, passes out of the cylinder not only without doing any useful work on the piston, but actually opposing its motion, thus increasing the prejudicial resistance of the condenser pressure. It also carries out of the cylinder the entire heat of its evaporation, none of which can be utilized.

A word of caution is necessary here as regards the pressure at the end of the stroke of the piston in a cylinder, when the expansion of the steam is carried considerably below the atmospheric pressure. Thus far, the assumption has tacitly been made that pure steam only is used in the engine; practically, however, there is a good deal of air mixed with it, derived not only from the atmospheric gases dissolved in the feed water, but also from the air pumped in by the feed pump, and also from the air leaked in through the various vacuum joints of the cylinder and its attachments. Now, this air appears upon the indicator diagram as steam pressure, and falsifies it to that extent. Moreover, the mixture of air with the steam diminishes to a certain extent the liquefaction of the latter by metallic contact, because it causes the pressure of the steam to be less than is due to its temperature. Further, all the pressure produced by the air present with the steam falsifies not only the steam pressures on the indicator diagram, but the power developed by the cylinder, because, as that air has to be pumped out by the engine, the power consumed in this pumping will about equal the power produced upon the piston by the air. By allowing a considerable inleakage of air to a cylinder, it can be made to appear to develop a much greater power than it really does, as computed from the diagram, and in experiments using steam very expansively, this error has frequently been inadvertently made, and to no small a degree. The temperature in the condenser rarely much exceeds 100° F., which corresponds to a saturated steam pressure of about one pound per square inch: now the mean pressure in condensers is about two pounds per square inch, being composed of steam and air in equal portions. And, still more, the mixture of air with the steam in the cylinder at the end of the stroke of the piston, causing the pressure there to be higher than is due to the steam, vitiates the calculation of the weight of steam present in the cylinder as such at the end of the stroke of the piston, making it appear larger than it is, and, consequently, making the liquefactions, as computed from the diagram, appear less than they really are.

The entire liquefaction of steam, due to the interaction of the metal of the cylinder takes place in the cylinder between the commencement of the stroke of its piston and the point of cutting off the steam, or closing of the cut-off valve. From that point to the end of the stroke of the piston; that is, during the expansion portion of the stroke of the piston, the expanding steam, with continuously lessening temperatures as well as pressures, is continuously abstracting heat from the metal of the cylinder and thereby cooling it, the temperature of the metal falling continuously from the temperature of the steam at the point of cutting off to that of the steam at the end of the expansion, or end of the stroke of the piston. After the exhaust valve opens, there is a still further expansion of the escaping steam accompanied with further lessening of the temperature of the metal of the cylinder. Now the whole of the steam liquefied to furnish the heat required to raise the metal of the cylinder from the temperature of the back-pressure steam to that of the entering steam, is liquefied in the cylinder between the opening of the steam admission valve and the closing of the cut-off valve. This is the liquefaction due alone to the interaction of the metal of the cylinder with the steam, but does not include the other causes of liquefaction of the steam.

If the metal of the cylinder remained constant at the temperature of the entering steam, there would be no liquefaction due to its interaction, but the liquefactions would remain the same that are due to other causes.

[*To be continued.*]

CORRESPONDENCE.

THE USE OF THE DIAMOND DRILL OF THE ANCIENT EGYPTIANS.

The Committee on Publications:

GENTLEMEN:—While preparing the lecture on "The Diamond Drill and its Work," which I had the honor to deliver, last February, before the FRANKLIN INSTITUTE, I wished to secure some authoritative confirmation of a published statement that the "diamond drill," or its equivalent, had been used by the ancient Egyptians. I, therefore, wrote the Hon. James G. Blaine, Secretary of State, asking his kind offices in the interest of science in securing from the Consul-General of the United States at Cairo, Egypt, answers to certain questions relative to the matter. These questions were very kindly forwarded by the Department of State, to the Hon. Eugene Schuyler, Consul-General of the United States at Cairo, whose reply did not reach me in time for incorporation in my lecture; and I now take great pleasure in fulfilling my promise by enclosing a copy of it to you, as it is a complete confirmation of the statements made by me relative to the use of "diamond drills," or similar tools, by the builders of the pyramids.

Yours truly,

W. F. DURFEE.

Birdsboro, Pa., July 26, 1890.

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[COPY NO. 46.]

Agency and Consulate-General of the United States.

CAIRO, EGYPT, March 1, 1890.

Hon. William F. Wharton, Assistant Secretary of State:

SIR:—In reply to your despatch No. 12, dated December 7, 1889, enclosing a letter from W. F. Durfee, of Birdsboro, Pa., on the use of diamond drills by the ancient Egyptians, I have the honor to say that, after consulting very many persons, I at last hit on the one man who has invented the theory—Mr. Flanders Petrie. I enclose a copy of a statement made by him on the subject. I have the honor to be, sir,

Your obedient servant,

EUGENE SCHUYLER.

—

[ENCLOSURE IN DESPATCH NO. 46.]

Statement of Mr. Flanders Petrie.

(1) The specimens of work which demonstrate the use of jewel points in sawing, drilling, etc., are drawn in my book, *Pyramids and Temples of Gizeh* (both editions); and the same plate is in the *Journal of the Anthropological Institute* for 1882 or '83, referred to in the chapter on "Pyramids and Temples," and in the *Journal*, but the account of mechanical methods in general is fuller in the *Journal.*

(2) There are no specimens in the Bulak Museum for the purpose of illustrating the subject; all the more able specimens are in my own possession, in England. But for a resident in Egypt, I would name the following examples that may be noticed:

(1) Base of tube-drill hole, cut too deep in roughing out the statue, between the feet of the diorite statue of Chephren (Kofra), in the Bulak Museum.

(2) Sides of two drill holes, showing on the inside of the sarcophagus at Gizeh; the marks are near the top, at the N. end of E. side, and on the W. end.

(3) Saw-cut too deep into the outside of that sarcophagus, on the N. end, near the top at N. E. edge.

(4) Saw-cut surface beneath sarcophagus in second pyramid, Gizeh.

(5) Drill hole, with core sticking in it, in granite lintel of chamber leading from the S. W. corner of the great hall of the granite temple of Gizeh; the fifth hole.

(6) I believe some small drill-holes are in the Hyksos head in black granite from Bubastir, in the Bulak Museum, the eye sockets having been cut out by drill-holes.

If casts are wanted, plaster-casts can easily be taken of Nos. 1, 2, 3, 4; and gutta-percha casts of Nos. 5 and 6.

NOTES AND COMMENTS.

CHEMISTRY.

LIQUID KINO.—By J. H. Maiden, Curator of the Technological Museum, Sydney. Proceedings of Royal Society of Victoria, 1890, p. 82.—*Angophora intermedia*, D. C., the narrow-leaved apple tree, is a tallish tree, which extends from Victoria to Queensland, as is the only species of the genus which is found in the southern colony. In the following respect it is perhaps unique among Australian trees. Frequently, when an incision is made into the bark, and more particularly when the knobby excrescences sometimes found on this tree, are cut, there exudes a watery liquid, which occasionally is almost as clear and colorless as water, and at other times of an orange-brown or reddish-brown color, and of the consistency of a thin extract, or even as thick as treacle.

This is doubtless the substance which was sent from New South Wales to the Paris Exhibition of 1867, labelled "apple-tree juice," with the statement that it is used as a varnish; but this is not correct, as the liquid is aqueous. It is used by fishermen for tanning their nets. Mr. Kirton informed Baron von Mueller that a single tree will yield as much as two gallons of liquid, which is generally called "liquid kino." This is a modest computation for the tree which yielded the Bangley Creek sample (*infra*)—yielded from eight to ten gallons. The quantity is in any case by no means small, and is dependent on a variety of circumstances.

Two samples of this "liquid kino" having recently been forwarded to

the Technological Museum, the author has had an opportunity of examining it.

(1) From Bangley Creek, Cambewarra, N. S. W., of a clear reddish-brown color, and in order to give precision to the tint, it is very like raw linseed oil, Strasburg turpentine, or dark balsam of copaiba, but redder than any of them. It has a specific gravity of 1·008 at 15° C., and an acidulous smell (owing to the presence of acetic acid), accompanied by an odor not so pleasant, and reminding one somewhat of spent tan liquors. It deposits a quantity of sediment of a buff color, consisting almost entirely of catechol.

It contains tannin, ·772 per cent.; "non-tannin," ·508 per cent. (Löwenthal's method). The water amounts to no less than 98·3 per cent. The catechol was not estimated in this sample.

(2) This was obtained from Cambewarra, but from a different locality. It is darker in color than the preceding sample, being of a rich ruby color. Like No. 1, it deposits a small quantity of sediment (catechol). This liquid kino had a specific gravity of 1·022 at 15° C., when received in April, 1888.

The following results were obtained in December to January, 1889: Tannic acid, 3·048 per cent. (of the liquid kino without evaporating); "non-tannin," 1·27 per cent. (a portion of liquid kino, kept in agitation so as to obtain a fair proportion of sediment, was added to water to make up the strength of one grain of liquid kino to the litre); water, 96·7 per cent. (after filtration from deposited catechol). The catechol and a little phlobaphene, filtered off, were found to be in the proportion of ·495 per cent. of the original liquid kino. Ether, agitated with the filtrate, took up ·15 per cent., of which one-third was estimated to be catechol and the remainder resin.

Mr. Kirton has recorded liquid kino from the Illawarra District of New South Wales, but since there appears to be no reason why it should be found in one colony more than another, it will doubtless also be obtainable in Victoria, most likely on application to fishermen. H. T.

EXPERIMENTAL CULTIVATION OF MYROBALANS IN SOUTH AUSTRALIA. Trade report in *Jour. of Soc. of Chemical Industry*, vol. viii, p. 226.—The *Adelaide Observer* for December 29, 1888, states that the South Australia, Forest Department intends to plant seeds of myrobalans of commerce, which have been received from India, with a view of ascertaining whether they can be cultivated in the colony. The plant is used in dyeing cloth and leather.

H. T.

BOOK NOTICES.

SPON'S TABLES AND MEMORANDA FOR ENGINEERS. By J. T. Hurst. Tenth Edition. New York: E. & F. N. Spon, 12 Cortlandt Street. 1889.

This smallest of engineers' hand-books, being just one-seventy-sixth part in bulk of its great contemporary (D. K. Clark's *Manual*), was made by an Englishman for use in Britain, and must of necessity give English measures and data. Accordingly we find that the ordinary English cart is stated as holding forty-five cubic feet, or two and one-half tons of clay; whereas,

our cart-load of dirt equals a cubic yard by measure and one and one-half tons by weight. English bricklaying is said to be measured by the rod, a means of estimating unknown to our artisans; that kind of work is done here by the cubic yard or by the 1,000 bricks, and English bricks themselves differ greatly in size from ours, as, for instance, the smallest bricks tabulated are those called "London stocks," which are 8¾ x 4¼ x 2¾ inches; ours, according to Trautwine, measure 8¼ x 4 x 2 inches. As no roofing tiles are used here, this information is foreign news only.

The data relating to masonry, on page 9, state very nearly our practice; but the stones named on page 10 are not indigenous to our soil, except granite.

Page 11 gives exclusively English materials and practice, and on page 12 the denominations of slate are purely English, and no aid, therefore, to the American artisan. Carpenter work on page 14 compares favorably with what we do, but to be available, the quantities should be given in accordance with our board-measure rule; and "deal standards," on page 15, have no meaning with us. The term "scantlings," on page 16, does not exist in the nomenclature of our work, and no "hard-and-fast" rules can be applied here to roof construction. There is a lack of statement of the properties of timber with rule units of strength, by the aid of which one can, with any kind of timber, adapt the same to the circumstances of any case.

Lathing is not an exact science in England. We find the statement on page 22: "One bundle of laths contains (nominally) 500 feet, frequently 360 feet." What kind of feet is not stated, nor the lengths of the lath. Perhaps these discrepancies are due to the laths being made of "fir" wood. Ours are of a different material.

The sizes of bolts, together with their heads, nuts and washers, are convenient for reference, and are near an average. As these proportions vary in every locality, every engineer will make his own rule from the material employed.

They furnish healthy washers in England, "half the thickness of the head and have twice the area." John Bull believes in being sure. A valuable addition to these general data would be the strength of bolts, which is just what the out-door engineer, on the spur of demand, wants to know from his vest-pocket manual.

The sizes given for rivets in any seam are those in ordinary use. But it is said: "In riveted joints, sectional area of rivets should equal that of plate after deducting rivet holes," which is the usual English statement, and is believed to mean the driven rivet, not the commercial size of the rivet, and plates and rivets are to be of iron; these qualifications, however, are not stated. There is some reason, nevertheless, for the rule as formulated, because the shearing resistance of iron is less than its tensional resistance, and the rivet gains in area of section in the riveting process.

This little book states: "There is no fixed value for the B. W. gauge. The only standard gauge is Whitworth's, of which Mr. D. K. Clark says: "It is entering into general use." Since the use of fewest words in the treat-

ment of every subject fits best here, therefore be it said: *The best gauge is that which gives the diameter and thickness in inches and decimals.*

We can hardly expect that sheet-iron dimensions and the weight of nails, and the like, given in this literary dot, will correspond with American practice. Such data can have only local value.

The English gallon is given, of course, and the weight of English coals. Manilla ropes are not mentioned, while much is said of hempen ones.

In reference to railway curves, on page 70, it may be said, how much better to employ the system, which gives the angle at the centre, or the angle between the two chords for a 100-foot chord, because there are no fractions to remember nor calculations to make, which certainly aid field practice. The centre, as a rule, is inaccessible, and the radius direct cannot be applied.

In a note to the condensed rules of mensuration, it is stated: "The prismoidal formula applies to earthworks, casks and truncated cones." It should have said that it will solve the solidity of every known regularly formed body, and for such a book as this a rule so general may be consistently inserted (in lieu of the host of them for solids, found in the larger books), with one worked-out example.

Under the head of "U. S. of America," the liquid gallon, which is most used in engineering calculations, is not given except by inference, and it should have been stated that the metric system of measures is not generally known or used.

While we have noted less than a score of extracts from the booklet, its 135 pages teem with engineering data invariably of value, having universal use.

We cannot say this volume adds much avoirdupois to the library shelf, but the adage, "precious goods come in small packages," is proven in this example, and, therefore, it should certainly find a place in the vest pocket of every engineer. J. H. C.

TREATISE ON LINEAR DIFFERENTIAL EQUATIONS. By Thomas Craig, Ph.D., Associate Professor in the Johns Hopkins University, Associate Editor of the *American Journal of Mathematics*. Vol. I: Equations with Uniform Coëfficients. New York: John Wiley & Sons. 1889.

Starting with the investigations of Fuchs, twenty-five years ago, the theory of linear differential equations has undergone rapid development, until now it has an extensive literature in the various periodicals. Prof. Craig has laid himself the task of collecting and presenting at one view this mass of material, thus making it available to a large number of students, to whom otherwise it would remain in great part inaccessible. The result is undoubtedly a treatise of great value, indispensable to the library of students in this department of mathematics.

Much of the matter is given nearly or quite in the form in which it appeared in the original memoirs. Notably is this the case in Chapter VII, which is a translation of Goursat's valuable thesis upon the linear differential equation that admits the hypergeometric series as an integral. In this chapter, the results of Gauss and Kummer are reviewed and the theory extended.

Similarly, Chapter IV is based upon Frobenius' paper, "Ueber die Integration der linearen Differentialgleichungen durch Reihen."

In Chapter I, the author reviews rapidly the general properties of linear differential equations; and, in Chapter II, he takes up equations having constant coëfficients, giving methods of Cauchy, Jordan and Méray.

Chapter III is devoted to a preliminary treatment of equations with singly and doubly periodic coëfficients. Some of the methods and results of Hamburger, Floquet and Jordan are given. The theory of groups is here introduced. It is further developed together with that of function-groups (the "faisceau" of Jordan), and of substitutions in Chapter XI. An application of the same theory is made in Chapter VIII to irreducible equations.

The theory of linear differential equations, all of whose integrals are regular, is continued in Chapter V; and in Chapter IX is discussed that of equations some of whose integrals are regular. Chapter VI is devoted to equations of the second order, having three critical points.

The subject of Chapter X is the decomposition of linear differential equations into symbolic prime factors. Some interesting analogies appear here between these equations and ordinary algebraic equations.

In Chapter XII, we find treated very briefly the case of equations whose integrals are rational, together with an allied class (Halphin's equations). The more general theory of equations whose integrals are algebraic is reserved for the subsequent volume.

Chapter XIII contains some account of the theory of transformation of a linear differential equation, particularly the reduction to Forsyth's canonical form. This involves something of the theory of invariants, the full discussion of which, together with that of equations with uniform doubly periodic coëfficients (the subject of Chapter XIV) is reserved for Vol. II. Chapter XIII contains, also, some account of Lagrange's associate equations.

Throughout the book the methods of the theory of functions are employed exclusively. The student will find, therefore, that a knowledge of these methods, as well as of the elementary theory of differential equations, is essential to success in reading the book.

In conclusion, we cannot refrain from adding a note of gratification at the issue of such a volume from an American press. It is one of the indications, which are becoming more common around us day by day, of the wide diffusion on this side of the Atlantic of a taste for advanced work in these higher fields of scientific research. C.

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE

[*Stated Meeting held at the* INSTITUTE, *Tuesday, September 16, 1890.*]

HALL OF THE FRANKLIN INSTITUTE.
PHILADELPHIA, September 16, 1890.

Mr. T. C. Palmer, President, in the Chair.

Members present: Prof. E. F. Smith, Mr. Reuben Haines, Dr. D. K. Tuttle, Prof. N. Wiley Thomas, Mr. A. A. Moore, Mr. Lee K. Frankel, Dr. Wm. H. Wahl, Mr. Fred. E. Ives. Prof. R. L. Chase, Mr. A. T. Eastwick, Mr. G. L. Norris and four visitors.

Dr. Tuttle proposed the name of Cabell Whitehead, of the Mint Bureau, of Washington, as an associate member of the section; the name was referred to the Committee on Admissions.

Dr. Wahl presented the paper by Dr. Masser, of Los Angeles, Cal., on "The Curve of the Elements," which was to have been read by Dr. Persifor Frazer. It was read by title, and on motion it was decided to refer the article to a special committee for publication. The President named Dr. Wahl, Dr. Hall and Prof. Smith as members of this committee.

Mr. Reuben Haines then read a thoroughly-prepared paper on "The Use of Galvanized Iron in the Conveyance of Drinking Water." Some interesting results of the analysis of water conveyed in galvanized pipes were presented, and also a careful review of the most important literature on the subject. The paper was referred for publication in the JOURNAL.

An interesting discussion followed in regard to the immunity enjoyed by workmen engaged regularly in handling poisonous metals and their compounds. Dr. Wahl instanced, as a remarkable example of this, the continual inhalation by the workmen in the galvanizing works of zinc chloride vapors, produced by throwing ammonium chloride upon the surface of the molten zinc in the operation of galvanizing iron.

Dr. Tuttle called attention to the carelessness in regard to health shown by workmen in white lead works. Remarks were also made by the President and by Mr. Reuben Haines.

Adjourned. WM. C. DAY, *Secretary.*

LECTURES FOR THE SEASON 1890–'91.

The following list embraces the Lectures arranged for the season 1890–91.

1890.

Nov. 10.—Prof. PERSIFOR FRAZER, D.Sc. Subject, *Some Helps and Hinderances to the Progress of Theoretical Chemistry.*

14.—Mr. C. J. HEXAMER. Subject, *From the Baltic to the Volga.* (Illustrated.)

17.—Dr. H. HENSOLDT, Columbia College, New York. Subject, *Some Methods and Examples of Mineralogical Research.*

21.—Prof. EDWARD D. COPE. Subject, *The Zoölogical Characters of Man.*

24.—Dr. BRUNO TERNE. Subject, *Ammonia: its Sources and Technical Uses.*

28.—Commander F. M. BARBER, U.S.N. Subject, *High Explosives in Warfare.*

Dec. 1.—Prof. G. G. GROFF, M.D., Bucknell Univ., Lewisburg, Pa. Subject, *The Organization of Sanitary Work in Cases of National Disaster.*

5.—Dr. L. WEBSTER FOX. (Subject to be announced.)

8.—Capt. F. A MAHAN, Corps of Engineers, U.S.A. Subject, *Philadelphia as a Seaport.*

12.—Mr. J. C. TRAUTWINE, C.E. Subject, *Engineering Notes from Europe.*

15.—Prof. WM. D. MARKS. Subject, *Two-and-a-half Miles a Minute.*

19.—Mr. FRED. E. IVES. Subject, *Photography in the Colors of Nature.* (Illustrated.)

29.—Dr. A. Victoria SCOTT. A Christmas lecture for the Children.—*A Trip to Alaska.* (With a series of fine views.)

1891.

Jan. 5.—Mr. JOHN CARBUTT. Subject, *Some New Applications of Photography.*

9.—Dr. LOUIS BELL, Editor *Electrical World,* New York. Subject, *Electricity as the Rival of Steam.*

12.—Prof. J. W. RICHARDS, Lehigh University, Bethlehem, Penna. Subject, *The Aluminium Problem.*

Jan. 16.—Mr. C. J. HEXAMER. Subject, *Light in the Dark Continent.* (Illustrated.)

19.—Prof. F. W. CLARKE, Washington, D.C. Subject, *The Chemical Elements.*

23.—Mr. C. J. H. WOODBURY, C.E., M.E., Boston. Subject, *Conflagrations in Cities.*

26.—Prof. ELIHU THOMSON, Lynn, Mass. Subject, *Induction of Electric Currents and Induction Coils.*

30.—Mr. F. LYNWOOD GARRISON. Subject, *New Alloys in their Engineering Applications.*

Feb. 2.—Dr. E. C. KIRK. Subject, *The Hygiene of the Mouth.*

6.—Mr. PARK BENJAMIN, New York. Subject, *Science in Modern Naval Warfare.*

9.—Mr. JOHN BIRKINBINE, Engineer. Subject, *The Development of the Pig Iron Manufacture in the United States.*

13.—Mr. GEORGE F. KUNZ, New York. Subject, *Occurrence of Gems and Precious Stones in North America.*

16.—Mr. OBERLIN SMITH, Bridgeton, N. J. Subject, *Possibilities of Applied Science.*

20.—Mr. HORACE L. PIPER, Assistant-General Superintendent, U. S. Life-Saving Service, Washington, D. C. Subject, *The Life-Saving Service.*

23.—Dr. H. A. SLOCUM. Subject, *Diseases and Remedies in the Light of Modern Medicine.*

27.—Mr. WALTER C. KERR, New York. Subject, *The Steam Loop for Returning Water of Condensation to Boilers.*

The DRAWING SCHOOL.

William H. Thorne, Director.

The Winter Term begins September 23, 1890, and ends January 8, 1891.

The Spring Term begins January 13, 1891, and ends April 23, 1891, when the closing exercises will be held in the Hall.

Each term comprises fifteen weeks, Tuesday and Thursday evenings.

Thorough instruction. based upon the most modern and approved practice, will be given in mechanical, architectural and free-hand drawing.

Admission to the Lectures of the Institute is free to the scholars on Monday and Friday evenings.

Tuition fee—$5 per term of fifteen weeks.

Tickets may be had at the Hall of the Institute, 15 South Seventh Street.

H. L. Heyl, *Actuary.*

THE SCHOOL IS DIVIDED INTO THE FOLLOWING CLASSES:

Junior Class, in which drawing tools and their proper manipulation, lines, surfaces and single solids with plane surfaces, are treated.

Intermediate Class, in which solids with curved surfaces, the intersections of solids, and the development of their surfaces, are treated.

All students are advised to go through these classes, in order thoroughly to understand the principles of draughting, before entering the Senior or the Architectural Class.

Senior Class, in which the methods, technicalities and style of draughting and designing engineering work, are treated.

Architectural Class, in which designs, plans, elevations and details ot buildings, and of interior and ornamental work, are treated.

Free-hand Class, in which free-hand drawing, with pencil and crayon from the flat and from casts, designing and oil-painting, are treated.

The class-rooms open at 7 P. M.

Instruction commences at 7.15 and ends at 9.15.

The full course comprises four terms, at the end of which certificates are awarded to those students who have shown sufficient attention, industry and progress.

In order that more efficient and rapid progress may be made, the Director has prepared text-books on mechanical drawing, with plates, which can be purchased at the class-rooms, together with all necessary tools and materials.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, September 17, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, September 17, 1890.

JOS. M. WILSON, President, in the Chair.

Present, 122 members and twenty visitors.

Additions to membership since last report, fourteen.

The President gave an account of his impressions of the Edinburgh Exhibition, which he had visited with the view to study and observation.

The following gentlemen were unanimously elected as honorary members of the INSTITUTE, having been recommended for such election by the Board of Managers:

Prof. E. MASCART, membre de l'Institute; Professor of the College of France, and Director of the Central Meteorological Bureau.

Mr. THEODORE TURRETTINI, Engineer, Geneva; Lt.-Col. Artillery, President of the City of Geneva; Director of the Works for the Utilization of the Motive-Power of the Rhone at Geneva, etc.; and

Prof. WM. CAWTHORNE UNWIN, F.R.S.; M.Inst.C.E.; Professor of Engineering at the Central Institution of the City and Guilds of London.

The Secretary reported that at the instance of the Committee on Science and the Arts, and with the cordial approbation of the Board of Managers, Mr. EDWARD LONGSTRETH, Vice-President of the INSTITUTE, had generously presented to the INSTITUTE the sum of one thousand dollars for the endowment of a medal of silver, to be designated as the "EDWARD LONGSTRETH MEDAL OF MERIT." The Secretary offered for inspection a specimen of this medal, whereupon Mr. SHAW offered the following resolutions, which were numerously seconded, and on being put to vote were unanimously adopted:

"*Resolved*, That the INSTITUTE hereby confirms the action of the Board of Managers in accepting the gift of foundation of the 'EDWARD LONGSTRETH MEDAL OF MERIT,' and in expressing its grateful acknowledgments for the gift.

"*Resolved*, That the grant of the EDWARD LONGSTRETH MEDAL—in accordance with the wishes of the donor—be entrusted to the Committee on Science and the Arts, subject to such conditions as the said committee, with the approval of the INSTITUTE, may impose."

Mr. ROBERT GRIMSHAW, M.E., of New York, read a paper on "Type-writing Machines." Discussed by Messrs. WIEGAND, LOCKWOOD and the author. (Referred for publication.)

Mr. W. N. JENNINGS exhibited and described a series of photographs of views, taken during a recent trip to the Pacific Coast.

Mr. G. M. ELDRIDGE called attention to a lot of samples of fabrics of

silk and other materials, woven on a knitting machine having bearded needles operated by cam motion. The machine is the invention of Mr. SAMUEL HOUGH, Jr.

The Secretary presented his monthly report, which embraced the following items of general interest, viz: An account of the construction of the railway tunnel under the St. Clair River, connecting Canada with the United States; an account of the progress on the work of the Nicaragua Canal; an account (with illustration) of the system of heating railway cars by steam, adopted, and about to be put in service by, the Pennsylvania Railroad Company. This description was prepared by Mr. THEO. N. ELY, General Superintendent of Motive-Power, and is referred for publication.

Mr. WM. E. LOCKWOOD called attention to the fact that a Committee of the Board of Trade was shortly to make an inspection of the plant for the purification of the Delaware River water by Anderson's process, that has been erected at Lardner's Point, by Mr. EASTON DEVONSHIRE; and expressed the hope that the sub-committee of the Science and Arts Committee of the INSTITUTE could co-operate with the first-named body.

He also placed on the Secretary's desk, and requested to be read, the following memorial to the National House of Representatives:

To the Honorable, the House of Representatives of the United States in Congress assembled:

This memorial of the Philadelphia Board of Trade respectfully represents—

That the National Museum, at Washington, D. C., with its valuable collection of specimens, affords educational advantages of incalculable value to the Nation;

That the government should make every effort to foster and encourage the further accumulation of such material as will mark historically the growth and progress of our country.

That ample provision should be made for the care, exhibition and safe-keeping of these accumulated treasures; therefore,

Your memorialist, the Philadelphia Board of Trade, earnestly petitions your honorable body to pass Senate Bill No. 2740, entitled "A Bill to provide for the erection of an additional fire-proof building for the National Museum."

And your memorialist will ever pray, etc., etc.

Mr. LOCKWOOD inquired if it would be in order for him to offer a similar memorial for adoption at this meeting.

The President stated that while the INSTITUTE, undoubtedly, warmly sympathized with the sentiments expressed in the memorial of the Board of Trade, and fully approved of its object—he deemed it inexpedient to depart from the uniform custom of the INSTITUTE in such matters.

Mr. ELDRIDGE referred to the fact that Mr. GRIMSHAW had some views to offer relative to the formation of a New York section of the INSTITUTE, whereupon Mr. GRIMSHAW was requested to favor the meeting with a statement of his views. At the conclusion of his remarks, Mr. GRIMSHAW was requested to address a communication on the subject to the Board of Managers.

Adjourned. WM. H. WAHL, *Secretary.*

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Proceedings of the Seventeenth Annual Meeting of the Association of the Alumni. From Willis G. Tucker, M.D.

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Childs, George W. Recollections of General Grant. From the Author.

Christensen, C. C. Graphical Diagram for Approximate Calculations.
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Smithsonian Institution. Index to the Literature of Thermodynamics. From the Institution.

Sociedad Cientifica "Antonio Alzate" Memorias Tomo 3. From the Society.

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Springfield (Ohio) Water Works. Tenth Annual Report. From the Superintendent.

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Texas Geological Survey. First Annual Report. 1889. Bulletin No. 4. From the Director.

Treat, C. R. Sanitary Entombment. From the Author.

Tucker, Willis G. Report to New York State Board of Health. From the Author.

Tyndall, J. Heat Considered as a Mode of Motion. From Spencer Fullerton.

PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

For AUGUST, 1890.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, August 31, 1890.

TEMPERATURE.

The mean temperature of 58 stations for August, 1890, was 68°·4, which is about 2°·0 below the normal, and 1°·1 above the corresponding month of 1889.

The mean of the daily maximum and minimum temperatures 79°·2 and 58°·5 give an average daily range of 20°·7, and a monthly mean of 68°·8.

Highest monthly mean, 73°·6 at Philadelphia.

Lowest monthly mean, 60°·1 at Wellsboro.

Highest temperature recorded during the month, 98° on the 3d at New Castle, and on the 6th at Gettysburg.

Lowest temperature, 34° on the 24th at Somerset.

Greatest local monthly range, 29°·5 at Huntingdon.

Least local monthly range, 13°·0 at Erie.

Greatest daily range, 47° at New Castle on the 16th.

Least daily range, 2°·0 at Grampian Hills on the 21st.

From January 1, 1890, to August 31, 1890, the excess in temperature at Philadelphia was 670°, at Erie 276° and at Pittsburgh 659°.

The warmest period of the month was from the 1st to the 4th, inclusive, and on the 17th, 18th and 19th. The coldest was on the 24th and 31st.

Light frosts were reported in several of the elevated districts on the 24th.

BAROMETER.

The mean pressure for the month, 30·03, is about ·05 above the normal. At the U. S. Signal Service Stations, the highest observed was 30·28 at Pittsburgh on the 24th, and the lowest 29·680 at Philadelphia on the 27th.

PRECIPITATION.

The average rainfall 5·76 inches for the month, is an excess of over 1·50 inches. The distribution was unevenly divided.

The largest monthly totals in inches were Carlisle, 9·65; Ligonier, 9·37; Gettysburg, 8·95; Mauch Chunk, 8·59; Uniontown, 8·44.

The smallest were Charlesville, 2·58; Philadelphia, 3·36; New Castle, 3·69; Pottstown, 3·80; Lock Haven, 3·83; Hollidaysburg, 3·87, and Meadville, 3·94.

Rains were of almost daily occurrence in some parts of the State. The heaviest occurred on the 8th, 18th, 19th, 20th, 21st, 22d, 26th and 27th.

On the 8th, Gettysburg reports a fall of 4·98 inches, and Carlisle, 3·04 inches.

WIND AND WEATHER.

The prevailing wind was from the west.

Local storms of great severity were numerous and destructive to life and property. The most notable occurred on the 19th, when at about 5·12 P. M. a terrific tornado from the Southwest passed over Wilkes-Barre. Sixteen persons were killed, and the damage to property is estimated at one million of dollars.

Average number: Rainy days, 12; clear days, 9; fair days, 14; cloudy days, 8.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Gettysburg, 5th, 19th, 29th; Charlesville, 5th, 21st; Blue Knob, 1st, 3d, 5th, 9th, 17th, 19th, 21st, 22d, 29th; Hollidaysburg, 29th; Le Roy, 5th, 9th, 17th, 19th; Forks of Neshaminy, 1st, 5th, 21st; Quakertown, 5th, 10th, 14th, 17th, 19th, 21st, 26th, 29th; Johnstown, 1st, 5th, 17th, 19th, 21st, 22d, 29th; Emporium, 1st, 5th, 9th, 17th, 19th, 21st, 29th; State College, 1st, 5th, 19th, 29th; Phillipsburg, 19th; West Chester, 1st, 6th, 18th, 19th, 21st, 29th; Coatesville, 1st, 8th, 10th, 14th, 18th; Kennett Square, 1st, 14th, 18th, 19th, 20th, 21st, 29th; Rimersburg, 5th, 9th, 17th, 29th; Grampian Hills, 12th; Lock Haven, 1st, 5th, 9th, 18th, 20th, 23d, 26th, 29th; Catawissa, 5th, 10th, 17th, 19th, 21st, 22d, 29th; Meadville, 1st, 3d, 4th, 5th, 17th, 19th, 21st, 22d; Carlisle, 1st, 5th, 21st, 29th; Harrisburg, 5th, 14th, 29th; Swarthmore, 1st, 5th, 10th, 18th, 19th, 21st, 22d, 30th; Erie, 4th, 21st, 29th; McConnellsburg, 1st; Waynesburg, 5th, 7th, 17th, 18th, 19th, 20th, 21st, 22d, 26th; Huntingdon, 1st, 5th, 21st, 22d, 29th; Petersburg, 5th, 22d; Myerstown, 14th, 17th, 19th, 21st, 22d, 29th; Coopersburg, 1st, 5th, 10th, 13th, 14th, 17th, 19th, 21st, 26th, 29th; Drifton, 5th, 10th; Wilkes-Barre, 17th, 18th, 19th, 26th; Nisbet, 1st, 5th, 8th, 17th, 19th, 21st, 23d, 26th, 29th; Greenville, 22d; Pottstown, 1st, 10th, 21st, 29th; Bethlehem, 2d, 5th, 6th, 10th, 13th, 17th, 19th, 21st, 29th; Philadelphia, 1st, 19th, 21st, 22d; Girardville, 5th, 21st, 29th; Selins Grove, 4th, 9th, 14th, 17th, 19th, 21st, 22d, 29th; Somerset, 16th, 17th, 21st, 22d; Eagles Mere, 3d, 9th, 29th; Wellsboro, 1st, 3d, 5th, 9th, 17th, 19th, 21st, 29th; Lewisburg, 1st, 5th, 9th, 17th, 19th, 21st, 22d; Columbus, 1st, 4th, 5th, 9th, 17th; Canonsburg, 22d, 29th; Dyberry, 1st, 6th, 10th, 17th, 19th, 22d, 26th; Ligonier, 1st, 5th, 19th, 29th; South Eaton, 2d, 5th, 9th, 10th, 14th, 17th, 19th, 21st, 22d, 26th, 29th; York, 1st, 6th, 8th, 14th, 18th, 19th, 21st, 22d, 25th, 26th, 30th; Phœnixville, 10th, 13th, 17th, 19th, 21st, 23d, 26th, 29th, 30th.

Hail.—Charlesville, 1st; Forks of Neshaminy, 1st, 5th; Huntingdon, 1st, 2d; Petersburg, 22d; Philadelphia, 1st, Lewisburg, 1st; Canonsburg, 29th.

Dew Point.	Precipitation. Total Inches.	Precipitation. Number of Days Rainfall.	Number of Days. Clear.	Number of Days. Fair.	Number of Days. Cloudy.	Wind. Prevailing Direction. 7 A. M.	Wind. Prevailing Direction. 2 P. M.	Wind. Prevailing Direction. 9 P. M.	Observers.
. .	8.95	13	7	13	11	SW	SW	SW	Prof. E. S. Breidenbaugh.
.0	4.06	12	6	15	10	N	N	N	Oscar D. Stewart, Sgt. Sig. Corps.
.7	2.58	8	8	18	4	N	N	N	Miss E. A. G. Apple.
.5	4.09	10	...	...	...	...	...	...	Dr. Charles B. Dudley.
. .	6.00	11	4	18	9	NW	NW	NW	A. H. Boyle.
.0	3.87	9	14	14	3	NW	W	S	Prof. J. A. Stewart.
. .	4.85	10	...	...	...	W	W	W	Miss Cora J. Wilson.
.0	5.71	13	4	10	17	SE	SE	SE	Charles Beecher.
. .	5.71	13	6	17	8	SW	SW	SW	Geo. W. T. Warburton.
. .	5.90	10	12	15	4	W	N	W	J. C. Hilsman.
.8	5.86	14	16	14	11	NW	NW	NW	J. L. Heacock.
.5	6.38	13	5	15	11	E	...	S	E. C. Lorentz.
. .	7.76	13	8	14	9	W	NW	NW	T. B. Lloyd.
. .	8.59	11	9	14	8	NW	NW	NW	John J. Boyd.
.4	5.46	11	8	17	6	W	W	W	Prof. Wm. Frear.
.	4.33	13	5	13	13	SW	SW	SW	Geo. H. Dunkle.
.0	5.87	17	13	12	6	W	NW	S	Jesse C. Green, D.D.S.
.	4.77	14	11	13	7	W	W	W	W. T. Gordon.
.	7.40	16	8	11	12	N	...	S	Benj. P. Kirk.
.0	4.94	14	6	13	8	NW	NW	NW	Knowles Croskey.
.	...	...	...	...	...	...	...	...	Prof. Wm. F. Wickersham.
.	...	...	12	12	7	NW	W	W	Rev. W. W. Deatrick, A.M.
.	...	...	...	...	...	...	...	...	C. M. Thomas, B.S.
.	6.41	12	3	21	7	W	W	NW	Nathan Moore.
.	3.83	9	17	8	5	W	W	W	Prof. John A. Robb.
.	5.44	13	...	...	...	...	...	...	Robert M. Graham.
.8	3.94	7	7	17	7	S	W	W	J. & B. H. Metcalf.
.0	9.65	14	7	18	6	W	W	W	J. E. Pague.
.6	5.70	15	10	13	8	W	W	W	Frank Ridgway, Sgt. Sig. Corps.
.9	4.38	10	1	15	15	N	NW	NW	Prof. Susan J. Cunningham.
.0	4.64	12	7	12	12	W	W	W	Peter Wood, Sgt. Sig. Corps.
.	8.44	9	12	17	2	...	...	...	Wm. Hunt.
.	...	...	...	...	...	...	...	...	Miss Mary A. Ricker.
.3	6.60	11	11	15	5	N	W	NW	Thomas F. Sloan.
.	5.45	9	...	...	...	...	...	...	Capt. W. C. Kimber.
.	4.40	9	24	3	4	W	W	W	Prof. W. J. Swigart.
.	4.58	12	12	15	4	W	S	S	J. E. Rooney.
.	...	...	...	...	...	...	...	...	Prof. S C. Schmucker.
.	...	...	...	...	...	...	...	...	C. A. Hinsdell.
.	...	...	...	...	...	...	...	...	C. N. Heller.
.	3.69	7	11	13	7	W	S	SW	Wm. T. Butz.
.0	5.12	15	15	7	9	W	W	W	Wm. H. Kline.
.	...	...	...	...	...	...	...	...	Geo. W. Bowman, A.M., Ph.D.
.	6.72	14	6	14	11	SE	SE	NE	M. H. Boye.
.	6.50	...	7	12	12	...	...	...	John C. Wuchter.
.	5.30	12	7	15	9	...	...	...	H. D. Miller, M.D.
.	5.44	12	15	5	11	SE	SE	SE	A. W. Betterly.
.	4.30	9	...	...	...	...	...	...	John S. Gibson, P. M.
.4	4.28	13	6	16	9	S	...	N	Prof S. H. Miller.
.1	5.27	15	6	18	7	NW	NW	NW	Culbertson & Lantz.
.0	3.80	13	13	14	4	W	W	W	Charles Moore, D.D.S.
.0	5.31	7	18	7	6	W	W	W	Lerch & Rice.
.0	3.36	12	4	14	13	NW	NW	NW	Luther M. Dey, Sgt. Sig. Corps.
.	6.48	14	17	7	7	NW	NW	NW	E. C Wagner.
.6	5.81	13	3	16	12	NW	NW	NW	J. M. Boyer,
.1	7.90	12	4	18	9	NW	NW	NW	W. M. Schrock.
.4	7.28	13	4	18	9	NW	NW	NW	E. S. Chase.
.8	6.89	16	6	10	15	N	N	NW	H. D. Deming.
.	5.78	13	5	22	4	SW	SW	SW	F. O. Whitman.
.0	6.20	16	8	13	10	SW	SW	SW	Wm. Loveland.
.5	6.89	14	7	19	5	SE	SE	SE	A. L. Runion, M.D.
.	6.35	14	4	17	10	W	W	W	Theodore Day.
.3	5.97	15	...	...	...	...	...	...	John Torrey.
.0	9.37	10	14	15	2	...	...	...	J. T. Ambrose.
.	7.53	17	4	21	6	NW	NW	NW	Benj. M. Hall.
.7	5.65	15	17	8	6	NW	NW	NW	Mrs. L. H. Grenewald.

T. F. TOWNSEND, *Sergeant Signal Corps, Assistant.*

Doylestown.	Lansdale.	Forks of Nesham'y.	Germantown.	Point Pleasant.	Bethlehem.	Canonsburg.	Carlisle.	McConnellsburg.	Waynesburg.	Lewisburg.	Mauch Chunk.	Nisbet.	Charlesville.	Lynnport.	Tionesta.
·11	·21	·24	·30	·07	. .	. .	·86	·60	. .	·67	. .	·20	. .	. .	.
. .	. .	. .	. .	. .	. .	. .	·05	. .	. .	·01	. .	. .	*	. .	.
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·10	·34	·54	·20	. .	·37	1·08	. .	·42	·50	·17	·02	·10	. .	. .	.
. .	. .	. .	. .	. .	. .	. .	1·37	·06	. .	. .	1·09	. .	. .	. .	.
. .	. .	. .	. .	·46	. .	. .	. .	. .	1·20	. .	. .	. .	. .	. .	.
·28	·12	·53	·38	. .	. .	·35	3·04	·86	. .	·05	·20	·20	·16	. .	.
. .	·23	. .	. .	·30	. .	·03	·35	. .	. .	·20	. .	. .	. .	. .	.
. .	. .	. .	·05	. .	·35	·06	. .	. .	. .	. .	·20	. .	. .	. .	.
·08	. .	. .	. .	·05	. .	. .	. .	. .	. .	. .	·02	. .	. .	. .	.
. .	. .	. .	·47	·01	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.
·16	. .	·14	·05	. .	·05	. .	. .	. .	. .	. .	. .	. .	. .	. .	.
. .	·20	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.
. .	. .	. .	. .	. .	. .	. .	·03	. .	. .	. .	. .	. .	. .	. .	.
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.
. .	. .	. .	·38	. .	. .	·45	. .	. .	·20	·87	. .	·50	·21	. .	.
·56	·35	·76	·45	·87	. .	·48	·33	·25	·15	. .	·98	. .	. .	. .	.
·29	·81	·03	·17	·16	1·29	1·10	·03	·57	·30	1·30	. .	·80	. .	. .	.
·71	1·21	·61	·80	1·15	. .	·13	·82	. .	·40	·27	1·55	. .	·24	. .	.
. .	·12	1·43	·54	. .	·27	·74	. .	1·93	1·10	·46	·17	·80	·53	. .	.
·88	. .	·09	·20	·98	. .	·41	1·23	·12	·40	·64	. .	. .	·11	. .	.
. .	. .	. .	. .	. .	. .	. .	·35	. .	. .	. .	·03	·20	. .	. .	.
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.
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. .	. .	. .	. .	. .	. .	1·47	·15	·81	1·20	·02	. .	1·20	1·08	. .	.
1·85	·68	·76	·32	1·15	1·79	·15	·97	·74	. .	·97	4·22	. .	·11	. .	.
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.
. .	. .	. .	. .	. .	1·19	·44	. .	·24	. .	·15	·11	·30	·14	. .	.
·39	. .	·77	. .	·81	. .	. .	·07	. .	. .	. .	. .	. .	. .	. .	.
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.
5·41	4·57	5·90	4·31	6·01	5·31	6·89	9·65	6·60	5·45	5·78	8·59	4·30	2·58	6·50	.

Frost.—Blue Knob, 24th; Catawissa, 24th; Waynesburg, 24th, 31st; Girardville, 24th, 28th; Somerset, 12th, 24th; Wellsboro, 13th, 16th, 24th; Lewisburg, 24th.

Sleet—Wellsboro, 17th.

Coronæ.—Charlesville, 1st.

Solar Halos.—Le Roy, 6th; Meadville, 16th, 17th, 18th; Eagles Mere, 16th; Phœnixville, 28th.

Lunar Halos.—West Chester, 28th; Carlisle, 30th; Coopersburg, 28th; Girardville, 28th; York, 28th; Phœnixville, 28th.

Meteors.—Blue Knob, 10th, 15th, 27th; Rimersburg, 10th; Meadville, 6th; Eagles Mere, 6th; Phœnixville, 9th, 10th, 16th.

Lunar Rainbow.—Greenville, 29th.

WEATHER FORECASTS.

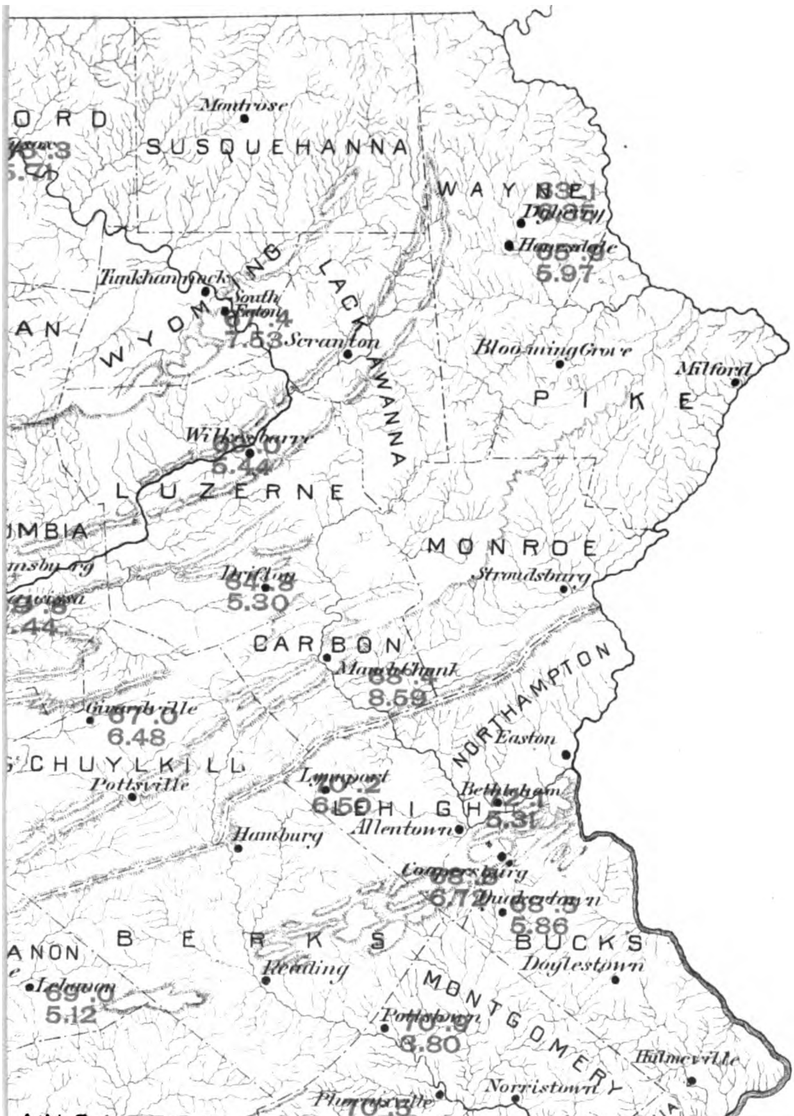
Percentage of local verifications of weather and temperature signals as reported by displaymen for August, 1890:

Weather, 82 per cent.
Temperature, 85 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
C. W. Burkhart,	Shoemakersville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
Capt. A. Goldsmith,	Quakertown.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
New Era,	Lancaster.
D. G. Hurley,	Altoona.

Displayman.	*Station.*
J. E. Forsythe,	Butler.
Steward M. Dreher,	Stroudsburg.
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. M. Wildman,	Langhorne.
G. W. Klee,	Chambersburg.
A. Simon's Sons,	Lock Haven.
Raftsman's Journal,	Clearfield.
R. C. Schmidt & Co.,	Belle Vernon.
Chas. B. Lutz,	Bloomsburg.
E. C. Lorentz,	Johnstown.
W. M. James,	Ashland.
Miller & Allison,	Punxsutawney.
Dr. A. L. Runion,	Canonsburg.
E. J. Sellers,	Kutztown.
C. A. Hinsdell,	Scranton.
H. M. Kaisinger,	Hartsville.
Foulk & Co.,	Milford.
William Lawton,	Wilmington, Del.
Wister Heberton & Co.,	Germantown.
Charles M. Mullen,	Bedford.
E. W. Merrill,	North East.
A. Simon's Sons,	Lock Haven.
Frank Ridgway,	Harrisburg.
G. W. Yost,	Collegeville.
A. C. Tryon,	Spartansburg.
A. H. Gerbench,	Annville.
Knowles Croskey,	Phoenixville.


SUSQUEHANNA
Montrose
WAYNE
Honesdale
5.97
Tunkhannock
South Eaton
7.53
WYOMING
Scranton
LACKAWANNA
Blooming Grove
Milford
PIKE
Wilkesbarre
6.44
LUZERNE
MONROE
Stroudsburg
Drifton
5.30
CARBON
Mauch Chunk
8.59
NORTHAMPTON
Girardville
6.48
Easton
SCHUYLKILL
Pottsville
Bethlehem
5.31
LEHIGH
Allentown
Hamburg
Coopersburg
Quakertown
5.86
BERKS
BUCKS
Reading
Doylestown
5.12
MONTGOMERY
Pottstown
Hulmeville
Norristown

Entered at the Post Office at Philadelphia in accordance with Section 199 of the Postal Laws and Regulations.

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Third Series. *NOVEMBER, 1890.* VOL. C.—No. 5.

CONTENTS.

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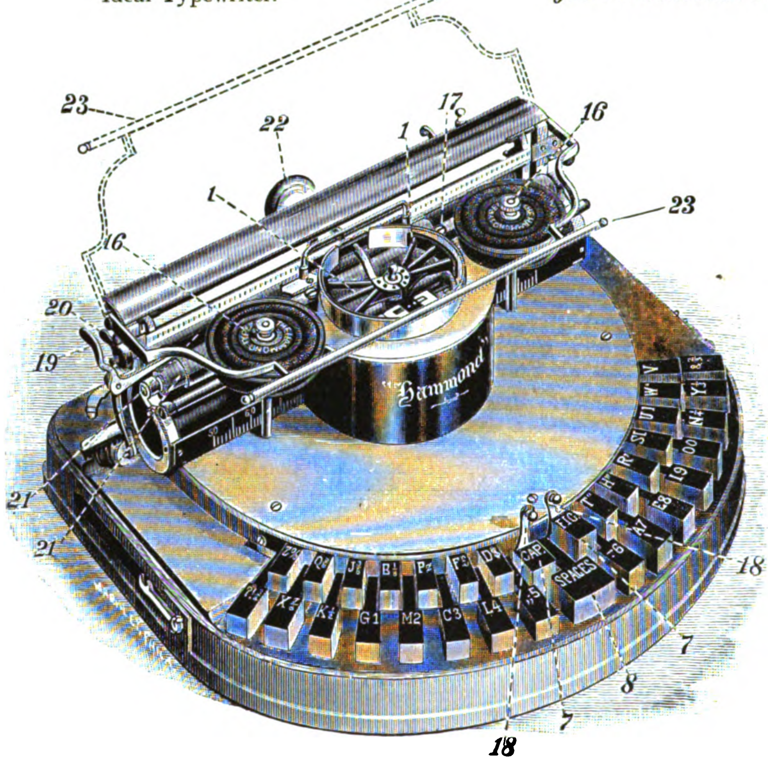
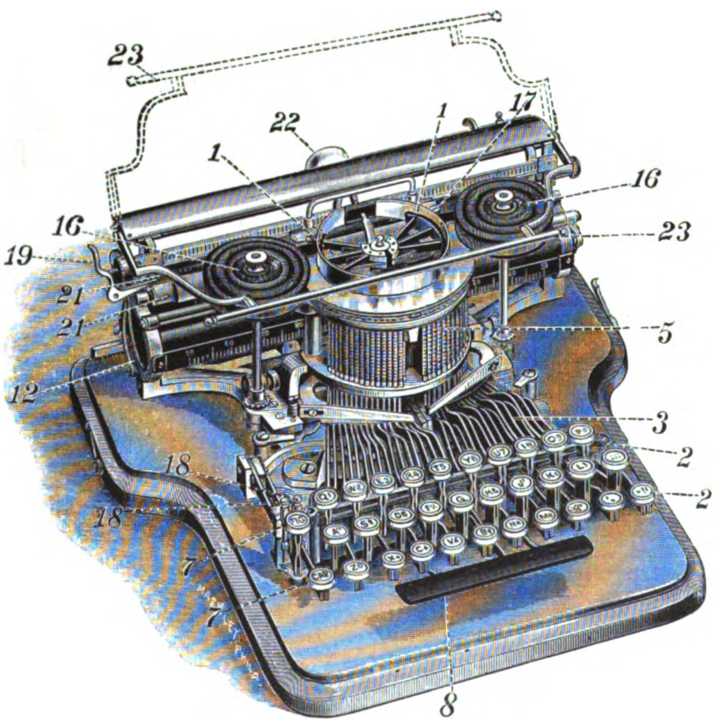
Ideal Typewriter.



Universal Typewriter.



JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXX. NOVEMBER, 1890. NO. 5

THE HAMMOND TYPEWRITER.

[*Report of the Committee on Science and the Arts.*]

[No. 1,555.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, September 3, 1890.

The Sub-Committee of the Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, to whom was referred for examination and report the

HAMMOND TYPEWRITER,

respectfully report that they have examined the said invention and find as follows:

That the invention is the subject of seven letters-patent of the United States, respectively numbered and dated as follows:

No. 224,088, dated February 3, 1880.
No. 224,183, dated February 3, 1880.
No. 232,402, dated September 21, 1880.

No. 249,930, dated November 22, 1881.
No. 253,475, dated February 7, 1882.
No. 290,419, dated December 18, 1883.
No. 290,420, dated December 18, 1883.

The invention consists of the combination of mechan isms by which the depressing of the key of any series can select a type or character from any one of two or three series as may be required, and impress such character upon a sheet of paper which is intermittently moved, horizontally to form the lines and letters or spaces, and vertically to pass from one line to another.

The device by which the selection from the different series of characters is made, the mechanism for selecting from the series, the mechanism for impressing the character so selected, and the mechanism for progressively moving the paper in two directions, when viewed together, present a rather formidable and complex appearance, and for a more clear and easy understanding of the subject, each of these separate mechanisms will be separately described, then the arrangement by which they are combined will be explained, and afterward a comparison of these mechanisms and their method of operation with those of other machines for like purposes will be made in this report, as the most easy and direct method of rendering the subject comprehensible.

The font of letters or types for the printing of characters is formed on cylindric segments oscillating on a common axis, which is vertical. They have a rising and falling motion to three different positions, and a horizontal vibration about the axis to fifteen different positions. There are two such segments containing the printing characters, each segment being capable of fifteen adjustments horizontally and three vertically. In other words, there are forty-five different adjustments, each adjustment selecting a different character, and, there being two segments, there are in all ninety characters, any one of which may be thus selected. The selection of characters in the horizontal direction is made by keys arranged in rows in a manual or key-board in front of the operator. Each key is connected with a lever operat

ing by means of a link and second lever, which cause the segment to turn horizontally; and the arrest of such horizontal motion at the proper point is effected by means of a bar or stop turning on the same axis as the printing segment, arrested at different points by means of pins, one of which is connected with each key and rises in the path of the lever, so as to stop it at the correct angular position. The selection of the lines of characters upon the segments in a vertical direction is effected by two keys other than those of the series in the manual, located at the left side of the key-board. Pressing one of these keys raises the printing segments, so that the line of numerals will be in position to print. This key may be locked in position, so that the key will constantly print numerals from the operation of the upper row of keys of the manual. The other key, for raising and lowering the printing segment, moves the segment to an intervening position and brings into play the capital letters. This key can also be locked, so that the typewriter, with this key locked, would continuously print capital letters. The depressing of the same key that brings the figures in position to print also with the keys of the middle and lower rows, brings into position a series of abbreviations, symbols and punctuation marks, such as the parentheses, colon, semi-colon, dollar mark, pound mark, cent mark, asterisk, paragraph, interrogation mark, degrees and exclamation mark; in short, all the usual conventional symbols employed in correspondence.

The mechanisms just described are for the *selection* of letters and other characters. The printing is done by the continued movement of the same key that has made the selection, liberating an impression plate or lever located back of the paper and directly opposite the selected letters.

The force of the impression is constantly the same because it is always measured by the reaction of the same spring under the same tension. (The action of this part of the machine is best shown in the skeleton machine sub mitted to the committee, an engraving of which is inserted in this report.) Connected with the impression mechanisms is a double pawl or pallet, working in the teeth of

an escapement wheel similar to escapement of a clock, which liberates with a step-by-step motion a carriage connected therewith by a rack and pinion, carrying the paper from the right to the left so as to receive the next letter after each character is impressed on the paper. Thus the paper is always ready to receive the impression of the next character until the end of the line is reached. A space key also operates this escapement mechanism so as to produce the spaces between the words. The returning motion, so as to commence a new line, is made by pushing the carriage from left to right. The force of the step-by-step propelling motion of the paper and carriage is the reaction of a spring coiled in a barrel or cylinder having teeth upon its periphery, which engage in corresponding teeth in the rack. The spring is wound up by the operator moving the rack from left to right at the commencement of each line. The tension of the spring is adjusted by a key and held to any required quickness of reaction by a ratchet wheel and pawl applied to the end of the arbor to which the central coils of the springs is attached. The progress from one line to the next in writing is made by a pair of rollers, which carry the paper through lengthwise and receive motion from a ratchet and pawl placed upon one end of the roller and operated by the lever, which is used when the carriage is returned to position for a new line. The coloring matter is conveyed to the place of printing by a ribbon saturated therewith, which is alternately wound gradually back and forth from two wheels located upon each side of the printing segments. The ribbon receives a slow progressive motion by means of the pawl and ratchet wheel, and connected screws and toothed wheels upon the lower ends of the reel arbors. The machine is provided with an adjustable stop contiguous to the rack which enables the operator easily to commence the lines at any definite point, the termination of the line being signalled by a small bell upon the back of the impressing lever.

The sheet of paper upon which the characters are impressed, passes upwardly between feeding rollers located below the point of impression, from a horizontal cylindric

space, open at the upper side and at the ends, so that any breadth of paper may be used in this machine, and so that large tabulated work is within the capacity of the machine, (which can not be done in other forms of typewriters,) the rollers and their connected parts being constructed so as to afford free space for the paper on both sides of the machine.

When a number of copies are required, two or more sheets of paper with carbon transfer paper laid between them are employed, and the impression produces an imprint upon the additional sheets.

The construction of the printing forms with all of the letters and printing characters fastened upon only two pieces of light material, avoids the difficulty and inconvenience experienced with typewriting machines of the type-bar class, when two keys are struck simultaneously. With the Hammond printing form there cannot be a collision between the types, whilst in machines of the class above-named, if two keys are struck simultaneously, as may happen in rapid working, they will either fail to reach the point of impression or will bend or break, and thus impair the usefulness of the machine.

In order that the keys of the several rows in the manual may act with equal force upon the selecting and impressing mechanism, the location of the fulcrum of the levers of each series is varied, so that precisely the same force is used upon each key of the impressing mechanism.

The several parts of the Hammond machine are secured to a substantial metallic bed plate, and are characterized by great compactness of construction.

By reason of the system of selecting upon forms and of arresting such forms by stops and pins controlled by the keys of the manual, exact adjustment for position of each letter and character is so effectually enforced that the alignment and spacing of letters in this machine is practically perfect.

The lightness of the working parts, the type forms being of small radius and light material, permits of a celerity of working impracticable in machines where gravitation chiefly must be depended upon to restore the letters or types to their normal position.

The details of the liberating mechanisms, for moving the paper carriage and making the impression, are shown upon the rear view of the skeleton machine better than in any other way, and have all the celerity and certainty of action that can be desired, depending upon a spring-propelled wheel controlled by an escapement similar to the anchor escapement of a watch.

When these machines were first introduced into use, the manual consisted of semi-circular rows of keys with latches to control the number and punctuation keys and the capital keys, the spacing key being a single broad key in the centre. Such machines whilst extremely serviceable in the hands of those familiar with them, were inconvenient to those trained to the use of other machines. This led to the present universal key-board machine, in which the several keys are arranged in right-lined rows, one above the other in a manual, thus rendering the machine convenient to the use of those trained with other typewriters.

The sub-committee deem it proper to call attention to the fact that the principle of operation employed in this typewriter imposes no limitation upon the speed of the operator, a fact which the sub-committee have verified experimentally.

So far as your sub-committee have been able to ascertain, the principle of selection employed in this machine is peculiar to it alone. Its general mechanical construction is excellent, the wearing surfaces are so extensive and well fitted as to ensure precision of action for a long time, and all of the parts are of such construction that they can readily be replaced. A font of letters may be removed from the machines cleaned or replaced, or another font substituted with the utmost facility.

[The details of construction of the Hammond machine are shown in the appended drawings and specifications of letters-patent, which would be too voluminous to rehearse in this report, and they could not accurately be described in more concise terms than in the specifications. Copies of all the patent specifications are hereto appended as well as copies of all other American patents, that appear pertinent

to the subject-matter involved in this invention and form an appendix accessible for reference in the library of the Institute.]

Celerity and certainty of operation, perfection of alignment, and great durability in service, are meritorious features which the Hammond machine possesses in an eminent degree, and the sub-committee commend it as the best typewriting machine that has come to their knowledge.

In conclusion, the committee believe that the invention of the impression and feeding mechanism, and especially of the unique principle of letter selection, as well as the perfection attained in the construction of this instrument are deserving of the highest award in the gift of the Institute, and the grant of the ELLIOTT CRESSON MEDAL to James B. Hammond, the inventor, is accordingly recommended.

S. LLOYD WIEGAND, *Chairman.*
JOHN L. GILL, Jr.,
LUTHER L. CHENEY,
N. H. EDGERTON,
EDWARD F. MOODY,
EDWIN S. CRAWLEY,
L. D'AURIA,
WM. C. HEAD,
JOHN HALL,
L. F. RONDINELLA,
J. H. EASTWICK.

Adopted, October 1, 1890.

H. W. SPANGLER, *Chairman Com. Science and the Arts.*

HART'S CLUTCH-HOIST.

[*Report of the Committee on Science and the Arts.*]

[No. 1,573.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 31, 1890.

The Sub-Committee of the Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, to whom was referred, for examination,

WALTER HART'S IMPROVEMENT IN HOISTING-MACHINES,

Report: That the subject-matter of this invention is fully described in letters-patent No. 372,908, dated Novem-

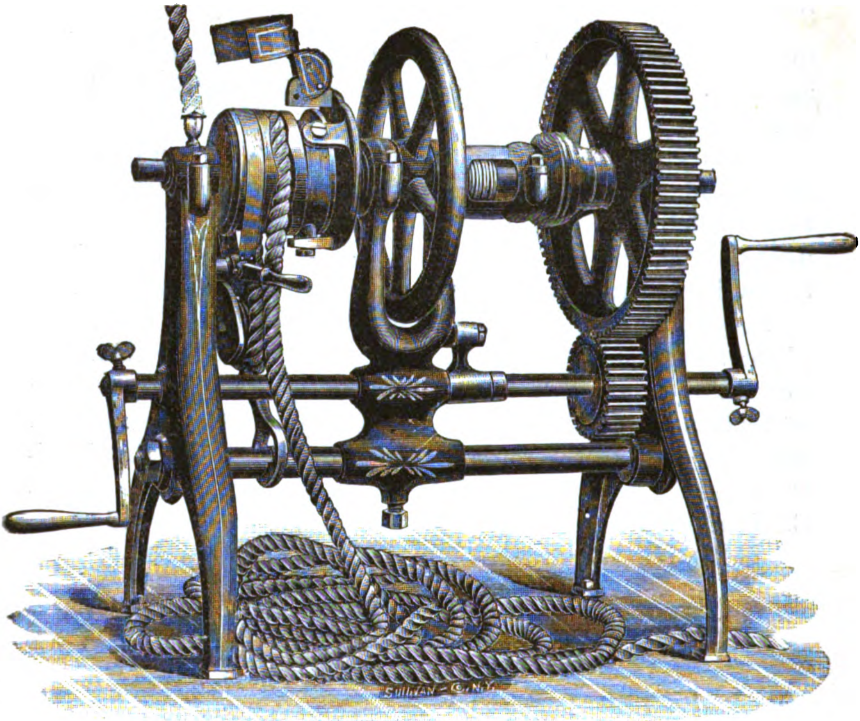


FIG. I. Hart's Clutch-Hoist.

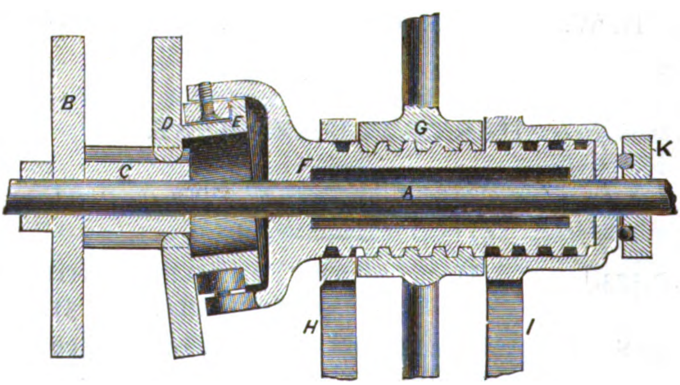


FIG. 2. Sectional View of Clutch.

A, shaft; *B*, plane-faced disc keyed to *A*; *C*, drum keyed to *A*, having four longitudinal grooves; *D*, a loose bevelled-faced disc, with lugs fitting in the grooves in *C*, and having channelled sleeve *E*; *F*, a threaded sleeve working on *A*, having four or more projections, each carrying an anti-friction roller; *G*, nut encircling *F*, held in place by standards *H* and *I*; *K*, collar keyed on *A*, and receiving thrust of shaft.

ber 8, 1887, a copy of which accompanies this report and is referred to for minute details of construction.

In the construction of hoisting machines appliable to the usual purposes of such devices, Mr. Hart employs in place of the common winding-drum, two discs, arranged

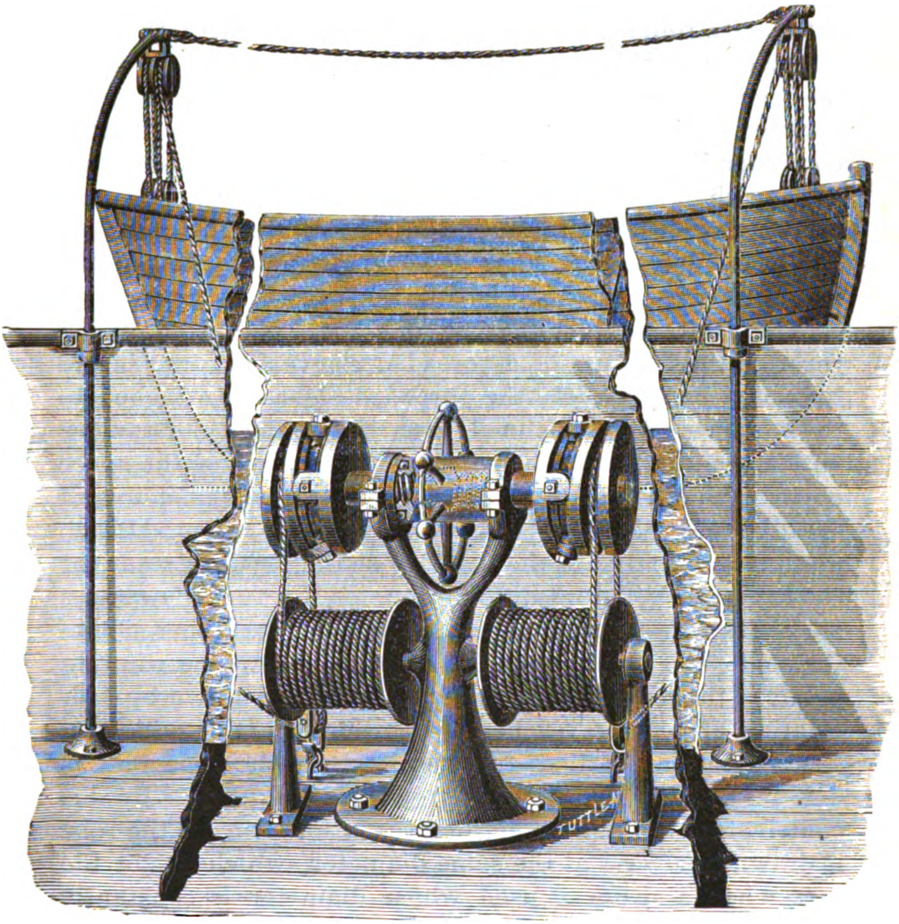


FIG. 3. The Clutch-Hoist applied for lowering Boats.

upon the shaft so that they will rotate in different planes; in other words, one disc having either a flat or slightly bevelled face, or in some cases a radially corrugated face, is firmly keyed to the winding shaft, while the other disc, which is cone-shaped, and in some cases corrugated like the

other, is mounted upon the shaft so as to permit adjustment towards and from the fixed disc, yet at the same time to rotate in a different plane.

To accomplish this, the movable disc is not directly secured to the winding shaft, but to a splined sleeve, and is held at the desired angle by a series of long and short arms, fitted with rollers, which travel in a groove with the hub, in the disc, so that while the rotation of the disc is made positive, it revolves in a plane not parallel with it, but inclined to that of the fixed disc, the angle of inclination corresponding to the bevel of its face, so that above the driving shaft the faces of the two discs are parallel to each other, while below the shaft the face of the inclined disc stands away from the other, at an angle double that of the inclination.

The lateral adjustment of one disc is accomplished through the medium of a threaded sleeve and a nut in the hub of a hand wheel; the threaded sleeve is attached to the supports of the inclined disc, but it does not revolve with the shaft, so that by turning the hand wheel the space between the two discs can be narrowed or widened to suit the diameter of the rope passing between them. When motion is imparted to the winding shaft, the discs rotate at the same speed, but at different angles, so that their faces are constantly approaching each other on the upper side of the shaft, and receding on the lower side. A rope running between the discs will be firmly clamped and drawn by their rotation, and as it reaches the lower side, the widening space between the discs releases it; thus the rope that is drawn in at one side is discharged at the other. By this contrivance, the pull upon the discs is uniform, as the rope is drawn in always at the same diameter, which is not the case when a drum is used whose diameter is constantly increasing by each lay of the rope. By use of the clamping screw and hand wheel, this hoisting-machine will grasp or release the rope instantly, and it is not necessary to stop the machine to stop hoisting, or to lower the load, as widening the space between the discs a very little allows the rope to run back freely any distance, and by a slight turn of the

hand wheel the discs can again be made to clamp the rope to hold or haul the load.

When this hoist is arranged as a boat-lowering device on vessels, two pairs of discs are placed on the winding shaft, so that the two ropes may be handled at equal speed.

For hauling in, two hand-levers are attached, one at either end of the winding shaft, and for lowering a brake is used for controlling the revolutions of the shaft, thus the rope, being held firmly by the discs, can be paid out uniformly or held at any point.

For precaution a curved metal guard is placed around the third (upper) circumference of the discs to prevent the rope from jumping out from between the discs, and as a guide to lead the rope into the discs a snatch block is used placed below and in front of the discs.

The simplicity of Mr. Hart's hoisting machine reduces its liability to derangement to a minimum, and as a boat-lowering device it is controlled and operated with entire safety by only one man.

That it is a serviceable hoist capable of drawing any load that the rope will sustain is beyond question, and there is nothing in the construction and operation of the hoist that would indicate any unusual wear upon a rope properly handled.

The number of purposes to which this hoist is practically applicable is very large, as its usefulness is extended beyond the limit of the drum hoists, for reasons which the inventor rightfully claims as follows:

It permits the use of ropes of any length.

It relieves the rope of all strain, except between the grip and the load.

It does not subject the rope to the rubbing wear as when wound upon a drum.

It requires always the same power for a given load, as it winds only upon one diameter.

It can take its first hold upon the rope at any point of its length.

It allows the use of both ends of the rope at the same time.

It allows rapid changes of ropes.

And, it is especially adapted for quick lowering or paying out.

The JOHN SCOTT LEGACY MEDAL AND PREMIUM is recommended.

H. R. HEYL, *Chairman.*
D. E. CROSBY, HERMANN DOCK,
THOS. P. CONRAD, ARTHUR L. CHURCH.

Adopted September 3, 1890.
H. W. SPANGLER,
Chairman of the Committee on Science and the Arts.

THE PROCESSES OF STEAM IN ITS DEVELOPMENT OF POWER BY MEANS OF A STEAM ENGINE.

BY CHIEF ENGINEER ISHERWOOD, U.S.N.

[*A Lecture delivered before the Sibley College of the Cornell University, Ithaca, N. Y., December 13, 1889.*]

[*Concluded from vol. c, p. 317.*]

The steam jacket is a contrivance for maintaining the metal of the cylinder at the temperature of the entering steam, and thus preventing the liquefaction due to the heat interaction of the metal; the liquefactions due to the other specified causes are not however affected by the jacket; it does not touch them. As the result of the prevention of the liquefaction due to the heat interaction of the metal, there is no water of liquefaction to be revaporized during the expansion portion of the stroke of the piston, therefore the pressure shown on the indicator diagram by the expanding steam would be less than in the case of non-jacketed cylinders, were it not for the increase of pressure caused by the higher temperature of the jacket. As a practical fact, the pressure of the expanding steam in both jacketed and non-jacketed cylinders closely follows the Mariotte law, the increased pressure due to the jacket temperature when the jacket is used, being about equalled by the increased

pressure due to the vaporization of water of liquefaction when the jacket is not used. The heat imparted to the metal of the cylinder by the steam jacket is entirely utilized in the production of power by increasing the pressure of the expanding steam—superheating it—the temperature of that steam being maintained constant throughout its expansion and equal to that of the jacket steam, so that the pressures of the expanding steam are in exact accordance with the Mariotte law. The water of liquefaction drawn from the steam jacket represents the heat that has been imparted to the expanding steam and wholly used by the latter in the production of increased pressure upon the piston. The net result of employing the steam jacket is the prevention of all the liquefaction caused by the heat interaction of the metal and the expanding steam, without expenditure of heat therefor. The steam jacket places the cylinder in nearly the economic position it would have, were it made of some adiabatic material, some material impervious to heat. If the cylinder metal were absolutely impervious to heat, the pressure of the expanding steam in a steam jacketed cylinder would be as much less than the pressure, according to the Mariotte law, as was due to the loss of heat transmuted into the power developed by that steam. James Watt considered the steam jacket to be his greatest invention, and there can be no doubt, from the point of view of intellectuality and complete originality, of the accuracy of that opinion, although he did not know either the rationale or the limits of its efficiency. It was a real inspiration of genius. The efficiency of the steam jacket is mainly connected with the expansive use of steam, and is in proportion to the measure of expansion with which the steam is used. When the steam is used without any, or with but little expansion, the advantage of the jacket is nothing or next to nothing, and how Watt, whose practice was restricted to low-pressure steam used with very little expansion, could have formed so high an opinion of its economic value under such limitations, is inconceivable. His estimate of its efficiency was strangely exaggerated, and the reasons he assigned for its

beneficial action were both erroneous and inadequate. After Watt, low pressures and small expansions remaining still the rule, the steam jacket fell into disuse, as its economic results in such cases proved too small to justify the construction expense and supervision trouble connected with its employment. However, since high pressures and large expansions have become the general practice, the steam jacket has been reintroduced, and the economic gain obtained by it under these conditions fully sustains the exalted opinion which its inventor always had of it.

Beside the steam jacket as a furnisher of heat externally to the metal of the cylinder, there are three other sources, namely, the heat carried by conduction from the valve chest of the cylinder, the heat generated by the friction of the piston, piston rod, and slide valve, and the sensible heat produced by the cushioning of the steam in the cylinder. The first two of these sources of heat are obvious, the last requires explanation.

The cushioning of the back pressure steam is effected by the closing of the exhaust port of the cylinder before the piston reaches the end of its stroke, thus imprisoning whatever back-pressure steam then remains in the cylinder. The piston, continuing to advance, compresses or "cushions" this steam, increasing not only its pressure by the compression, but its sensible heat by the thermal equivalent of the work done by the compression. Now the back-pressure steam thus heated by the work of compression, is in contact at the commencement of the compression with the metal of the cylinder at the temperature of the back pressure just previous to the commencement of the compression. From the moment, therefore, that the cushioning commences, the cooler metal takes up heat from the cushioned steam and liquefies an equivalent portion of it. This continuous compression, generation of sensible heat and abstraction of the same by the metal, continues until the end of the stroke of the piston is reached. The metal thus abstracting a large portion of the heat of compression, has its own temperature correspondingly increased, with the economic result that less of the steam entering from the

boiler on the opening of the steam port is liquefied by that metal. The compressed back-pressure steam having its temperature at the commencement of the compression the same as that of the metal with which it is in contact, increases very slowly in pressure owing to this abstraction of heat, and a great deal of compression is required to produce much of a "cushion" curve on the indicator diagram. The experimental curve varies enormously from the theoretical one. In fact, considerable reduction of space takes place before the curve sensibly commences; the liquefaction by the cool metal being equal to the compression. When the compression has reached a certain degree, and consequent high temperature, the liquefaction of the compressed steam has become so great that there is no further increase of pressure, and the curve rather abruptly changes to nearly a horizontal line, showing that the abstraction of heat from the steam by the metal has become equal to the heat put into the steam by the compression. This appearance can always be observed on the diagram if the steam eccentric be set "late" so as not to give "lead" to the entering steam, but, on the contrary, opening the steam port a little after the piston has commenced its return stroke. When there is steam "lead" this appearance is masked, but it is always there, and the cause of it renders any cushioning up to the pressure of the entering steam very difficult to obtain; hence, notwithstanding the greatest practicable amount of cushioning, some steam lead is always found necessary to fill the waste spaces at the end of the cylinder with steam of boiler pressure at the commencement of the stroke of the piston. Were it not for the air mingled with the back-pressure steam, the "cushion" curve would be much less than it appears on the indicator diagram.

Evidently, all the heat of compression put into the back pressure by the cushioning, that was abstracted by the cooler metal of the cylinder upon which the cushioning was effected, went to increase the temperature of that metal, and to thereby reduce its liquefying power upon the steam entering from the boiler on the opening of the steam valve.

The temperature thus imparted was a clear thermal gain; the bulk of pressure cushioned reproducing the power expended in the cushioning. The entire indicator diagram, measured down to the zero line of pressure, represents the entire dynamic effect of the steam per stroke of piston; the weight of steam expended to produce this diagram is also evidently the weight entering the cylinder per stroke of piston from the boiler plus the weight of the cushioned steam; and, just as evidently, the weight of steam entering the cylinder from the boiler per stroke of piston produces the whole of the diagram, excepting the cushioned portion, that is, the portion between the zero line and the back pressure line during the cushioning portion of the stroke of the piston, so that, consequently, this portion must be produced by exactly the weight of steam cushioned. Hence, there is neither loss nor gain dynamically by cushioning; but there is in all cases the thermal gain described.

As an illustration of the effect exerted upon the cushioning by the temperature of the metal of the cylinder, may be stated that the cushion curves formed with the same mechanism, the same back pressure, and the same point of closing the exhaust port, are very different, according as the steam entering the cylinder is of higher or lower pressure. As the pressure of the entering steam is lowered—its temperature lowering with its pressure—the temperature of the metal of the entire cylinder is lowered, the same measure of expansion being used, so that when the cushioning commences, the back-pressure steam is compressed upon metal of lower temperature than would have been the case had the entering steam been of higher pressure and temperature. The result appears on the indicator diagram in the smaller curves of the cushioning, these curves becoming less and less marked as the pressure of the entering steam is more and more lowered. The curves, as the entering steam is lowered in pressure, seem to commence later and later and to rise to a less and less height, the liquefaction during the compression becoming greater and greater in proportion to the less and less temperature of the metal of the cylinder.

There is an absolute practical necessity in order to

avoid shock from concussion, to bring the piston and its attached parts to rest slowly as the end of the stroke is approached, and to have the waste spaces at the end of the cylinder filled with steam of the boiler pressure ready for the return stroke, and to have such an opening of the steam port as will maintain this pressure with the moving piston up to the point of cutting off the steam. All this is accomplished by giving the steam valve "lead;" but the method entails a serious economic loss. The steam admitted during the lead simply adds to the back pressure against the piston, and nothing is recovered from it; the additional back pressure is a total dynamical loss. Hence, these waste spaces should be filled as much as possible by cushioned back pressure, and the "lead" reduced to the minimum possible. In this way, if the setting of the valve has been judiciously done, a further gain can be indirectly made by cushioning.

There has been shown in the case of a non-steam-jacketed cylinder, that during the portion of the stroke of its piston between the commencement of the stroke and the point of cutting off the steam, the cylinder acts as a surface condenser, liquefying sufficient of the entering steam to furnish the heat needed to raise the temperature of the metal of the cylinder from the back pressure temperature to the temperature of the entering steam. But from the point of cutting off to the end of the stroke of the piston, and during the whole of the exhaust stroke, the cylinder acts as a boiler, boiling off and revaporizing the water of liquefaction deposited on the metallic surfaces during the portion of the stroke between its commencement and the closing of the cut-off valve. Now, there can be known by calculation whether all of this water of liquefaction is revaporized during the expansion portion of the stroke of the piston, or whether some of it is revaporized during the exhaust stroke while the exhaust port is open. If it is wholly vaporized during the expansion portion of the stroke, leaving nothing to be boiled off during the exhaust stroke, a very valuable and interesting result follows, namely, the determination experimentally by weight of nearly all the steam liquefied by molecular action

as distinct from the weight of steam liquefied by metallic interaction, both being experimentally determinable.

There has been shown that the liquefaction of steam in a cylinder doing work is of two entirely different kinds, due to distinctly different causes: one kind is the result of the heat interaction of the metal of the cylinder with the steam, whereby the varying temperature of the metal with which the steam is in contact, alternately liquefies and re-evaporates the steam. This is a surface liquefaction and revaporization, the action being on the boundaries of the steam as a mass, and not molecularly within the steam. The whole of the water of liquefaction of this kind is present as water in the cylinder at the point of cutting off, and the difference between the weight of steam present as such at this point, calculated from the pressure there, as shown on the indicator diagram, and the weight of feed water pumped into the boiler gives the weight of steam liquefied by this cause.

Now, suppose the entire weight of water of liquefaction present in the cylinder at the point of cutting off, to be vaporized during the expansion portion of the stroke of the piston, then, if there were no liquefaction due purely to the molecular actions of the steam, the weight of steam present as such in the cylinder at the end of the stroke of the piston, calculated from the pressure there, as shown on the indicator diagram, should be the same as the weight of feed water pumped into the boiler. It cannot be more, and, if less, the difference is wholly due to the molecular liquefactions of the expanding steam hereinbefore described from leaving the boiler to arriving at the end of the stroke of the piston. Now, if the aggregate weight of these calculated molecular liquefactions, added to the weight of the steam determined at the end of the stroke of the piston by the indicator, equals the weight of feed water pumped into the boiler during the same time, all the water of liquefaction due to the interaction of the metal of the cylinder, has been vaporized during the expansion portion of the stroke of the piston; but, if the weight thus obtained be less than the weight of water pumped into the boiler, then the difference is the weight of water of liquefaction due to the interaction

of the metal of the cylinder vaporized during the exhaust stroke of the piston.

Up to the present moment, there is universally held in the case of a condensing engine using the steam expansively and having the boiler fed with water from the hot well, that when the exhaust steam is liquefied in the condenser by the application of cold condensing or injection water, the entire heat present in the steam in the boiler will be recovered in the injection water and in the heat (ascertained by calculation) transmuted into the external work done by the expanding steam. This belief, however, is entirely erroneous; the heat ascertained as above being always greatly less than the heat present in the steam in the boiler. This fact is easily ascertainable experimentally, and is shown by every experiment that has ever been made in which the weight of the injection water, and its initial and final temperatures have been given. In fact, the difference between the quantity of heat present in the steam in the boiler, and the quantity of heat present in the injection water after its liquefaction of the exhaust steam, is exactly the quantity of heat lost as such by being transmuted into the various molecular actions of the steam while passing through the engine from the boiler to the condenser, including the heat transmuted into the external work of the expanding steam. If, now, from this difference there be subtracted the heat transmuted into the external work done by the expanding steam, a quantity easily calculable, the remainder will be the heat transmuted into the other molecular actions of the steam while passing through the engine from the boiler to the condenser. Thus, not only the fact, but the amount of these molecular actions can be shown experimentally, proving beyond the possibility of doubt the accuracy of the previsions herein shown both qualitatively and quantitatively. The quantitative result will not be affected by the loss of heat from the external radiations of the boiler, of the steam pipe, and of the cylinder; but it will be affected, and to the amount of the heat thus radiated, by the external radiations from the exhaust pipe, from the condenser, from the air pump, and from the hot well. If these latter, how-

ever, are well protected by non-heat conducting material, and they should be during an experiment, the loss of heat from this cause will be insignificant.

The loss of heat by radiation from the external surfaces of the boiler, steam pipe and cylinder, increases the consumption of fuel in the furnace, because the resulting water of liquefaction has to be revaporized, but does not affect either the weight of steam used, as measured by weight of feed water pumped into the boiler, nor the quantity of heat present in it.

The final generalizations are as follows:

The entire liquefactions of steam in the cylinder of a working steam engine are due to the transmutation of part of the *vis viva* of the steam molecules into either internal or external work—into either mass *vis viva* or into increased molecular *vis viva* of a smaller number of molecules.

This transmutation is only possible when the steam is used expansively; consequently, when it is used without expansion, there is no liquefaction, or "cylinder condensation" properly so-called. The heat above the heat in the feed water, found in the water of liquefaction deposited on the interior surfaces of a non-steam-jacketed cylinder is exactly equal to the heat absorbed from the metal of the cylinder by the expanding steam from the point of cutting off to the delivering of the steam into the condenser. All other liquefactions from the boiler to the condenser are due to the molecular work of the steam undergoing expansion from the various causes in action, and are not affected by the metal of the cylinder.

The water of liquefaction deposited on the interior surfaces of the cylinder is only made possible by the variations in temperature of the metal of the cylinder, caused by the similar variations in the temperature of the expanding steam, consequently when the variation of the temperature of the metal of the cylinder is rendered impossible by the employment of a steam jacket capable of maintaining the metal of the cylinder at the constant temperature of the boiler steam, there is no deposition of water of liquefaction on the surfaces of the cylinder, and the losses of heat are

confined to what belong to the molecular actions of the steam alone.

The losses by the interaction, of the metal of the cylinder with the heat of the steam, are preventable by the employment of a steam jacket, but not the losses by the molecular action of the steam.

The entire losses of heat, to which the so-called "cylinder condensation" is due, are caused by the use of the steam expansively, and are greater with greater measures of expansion.

As regards the measure of expansion with which steam can be most economically used, a limit is, therefore, soon reached in practice, depending on the boiler pressure, the back pressure against the piston, the pressure required to work the engine *per se*, and on the use or non-use of the steam jacket, when the losses caused by the expansion neutralize the gain due to the expansion, the practical limit of expansion is attained, and, if it be carried further, loss will be experienced.

Thus far, no reference has been made to the obvious loss of heat from a cylinder by external radiation, in order not to complicate the essentials of the problem by mingling non-essentials with them. The loss by radiation can be reduced by suitable coverings of non-heat conducting materials until it becomes nearly insensible, and such should always be the case with practical steam engines.

Whatever liquefaction of steam due to external radiation there may be in a cylinder, will take place during the entire stroke of its piston, but, of course, will be greater at those parts of the stroke where the pressure is greater. This water of liquefaction will be revaporized in whole or in part under the lessening pressures in the cylinder due to the expansion of the steam, and the resulting steam will be utilized as pressure on the piston, but any part of this water that may be vaporized during the exhaust stroke will pass to the condenser as steam without doing work on the piston. The heat of vaporization of this latter part will be wholly lost.

The cooling of the metal of the cylinder by this abstrac-

tion of heat, caused by the revaporization of the water of liquefaction due to the external radiation, has to be restored by heat taken from the steam entering from the boiler, consequently there will be a liquefaction additional to those already described, in the cylinder between the commencement of the stroke of the piston and the point of cutting off the steam, equivalent to the heat lost by radiation.

The greater the loss of heat by steam liquefaction in the cylinder, the greater, proportionally to power developed by the engine, will be the work done by the air pump in discharging the greater quantity of mingled injection water and water of steam liquefaction, and of air and vapor, because the greater will be the weight of steam used per unit of time per unit of power. Also the greater will be the work done by the feed pump.

In order that steam may flow from one vessel to another, as from a boiler to a cylinder, or from a cylinder to a condenser, the pressure in the receiving vessel must be less than the pressure in the delivering vessel, and, as a consequence, the steam is expanded during the operation by the difference due to the two pressures. Now this expansion commences at the orifice by which the steam leaves the delivering vessel, and it continues to the receiving vessel. The steam is thus really transported by its own expansion, and is not pushed forward by the pressure in the delivering vessel as a piston is pushed forward by water pressure in a hydraulic cylinder. The delivering vessel maintains a supply of steam of the pressure in it at the orifice and that pressure acts as a fulcrum or surface of resistance for the expansion. There thus results that the work of transportation of the steam from the boiler to the cylinder, and from the cylinder to the condenser is done at the expense of the heat in the expanding steam which suffers, consequently, a proportional molecular liquefaction due, first, to the work of expansion and, second, to the increased latent heat of the steam after its expansion. The pressures of the steam thus expanding form a curve similar to the curve of the expanding steam on an indicator diagram. For these reasons the economy of a steam engine is considerably affected by the

length of the steam pipe—supposing it to have no external radiation—and by the length of the exhaust pipe. The longer the steam pipe, the greater will be the difference between the pressure in the boiler and in the cylinder before the point of cutting off, and the greater this difference the greater will be the liquefaction in the cylinder. The longer the exhaust pipe the greater will be the difference between the pressure in the condenser and the back pressure against the piston, and the greater will be the liquefaction in the cylinder. Also the higher the steam pressure used in the boiler, the greater will be the difference between that pressure and the pressure in the cylinder previous to the point of cutting off the steam. And the greater the pressure of the steam in the cylinder at the end of the stroke of its piston, the greater will be the difference between the back pressure against the piston and the pressure in the condenser.

The throttled use of steam does not affect its economic result in any sensible degree. Throttling is an imperfect method of using the steam expansively. It is attended by some gain due to the expansion, and some gain due to the difference between the temperatures before and after the throttling. It is attended by the liquefaction losses due to the expansion *per se*, and *due to the transportation of the steam from the boiler to the cylinder under the lessened pressure of the throttling*, and due to the external work of the expansion. The gains are so nearly equivalent to the losses that the net result is sensibly nothing.

There now remains to make an application of the principles hereinbefore enumerated and demonstrated, to the case of a non-jacketed steam cylinder of a simple engine using saturated steam expansively:

(*A*) As regards the transportation of the steam from the boiler to the cylinder; let P be the steam pressure in the boiler in pounds per square inch above zero, and P' the steam pressure in the cylinder at the point of cutting off, in pounds per square inch above zero. Let V be the number of cubic feet of steam of the pressure P drawn from the boiler per hour, and V' the number of cubic feet of steam of the same

aggregate weight in the cylinder at the pressure P'; then $V' - V$ will be the difference of the two bulks of steam in cubic feet. This difference has been forced into the cylinder against the pressure P', and there has consequently been done per hour the number of foot-pounds of work represented by $V' - V \times P' \times 144$, the 144 being the number of square inches in a square foot. The heat or *vis viva* transmuted into this work has been furnished by the expanding steam itself, which has undergone a corresponding liquefaction. The quantity of heat so transmuted is given in Fahrenheit units, by dividing the number of foot-pounds of work by the mechanical equivalent ($789\frac{1}{4}$ foot-pounds) of one Fahrenheit unit of heat: hence,

$$\frac{V' - V \times P' \times 144}{789\frac{1}{4}}$$

equals the number of Fahrenheit units of heat transmuted into the work of transporting the steam from the boiler to the cylinder. Dividing this latter quantity by the latent heat of the mean pressure due to the pressures P and P', there will be obtained the number of pounds weight of steam liquefied to furnish the above number of Fahrenheit units of heat.

(B) Now there was a further liquefaction of this steam due to its increased latent heat after expansion. Let L be the latent heat at the pressure P, and L' the latent heat at the pressure P'. Then

$$\frac{L' - L}{L}$$

will give the fraction which the difference of the latent heats is of the latent heat at the pressure P. Multiplying the weight of steam in pounds per hour drawn from the boiler by

$$\frac{L' - L}{L},$$

there will be obtained the weight in pounds per hour of steam liquefied in consequence of the increase of its latent heat when expanded from the pressure P to the pressure P'. Multiplying this latter weight by $L' - L$ gives the number

of Fahrenheit units of heat transmuted into the work of expanding the steam *per se*.

(*A*) + (*B*) gives the total quantity of heat stricken out of existence as such, by being transmuted into the mass and molecular work of transporting the given weight of steam per hour from the boiler to the cylinder.

(*C*) After the closing of the cut-off valve, the steam commences to expand, doing external work, and continues the expansion until the piston has reached the end of its stroke. The mean pressure of this expansion must be obtained from the indicator diagram, as it cannot be calculated. Now this mean pressure in pounds per square inch above zero, multiplied by the number of cubic feet of space displaced per hour by the piston corresponding to the expansion portion of its stroke, and by 144, will give the number of foot-pounds of work done per hour by the expansion of the steam. The heat or *vis viva* transmuted into this work has been furnished by the expanding steam itself, which has undergone a corresponding liquefaction. The quantity of heat so transmuted is given in Fahrenheit units by dividing the number of foot-pounds of work by the mechanical equivalent (789¼ foot-pounds) of one Fahrenheit unit of heat. Dividing the number of Fahrenheit units of heat so obtained per hour by the latent heat of the mean pressure of the expanding steam, gives the number of pounds weight of steam liquefied per hour to furnish the above number of Fahrenheit units of heat.

With the immediately above calculation the weight of steam liquefied in the cylinder previous to the commencement of the expansion has no connection. The indicator diagram shows that a certain number of foot-pounds of work has actually been done by the steam during the expansion, and from that amount of work the number of Fahrenheit units of heat transmuted are calculated.

(*D*) Now there was a further liquefaction of the expanding steam, additional to that due to the work of expansion performed (*C*), caused by its increasing latent heat as its expansion proceeded. To calculate this quantity, there must be known the weight as well as the pressure of the expand-

ing steam, and this weight cannot be precisely known. At the commencement of the expansion, the weight of steam per hour, as such, in the cylinder is the difference between the weight drawn from the boiler per hour, and the weight liquefied in the cylinder between the commencement of the stroke of the piston and the point of cutting off the steam, but during the expansion a considerable portion of this water is revaporized, the revaporization being gradually effected from the beginning to the end of the expansion, and, as a result, the weight of steam is different at every point in the expansion curve. To approximately calculate the liquefaction of the expanding steam due to the increase in its latent heat, the expansion curve on the indicator diagram must be divided into a number of equal parts—the greater the number the more accurate the result—and the weight of steam, as such, in the cylinder must be calculated from the pressure on the curve at each end of each of these parts, and the mean taken for each part as the weight of steam present for that part. The latent heats must also be obtained for the pressures at each end of each part. Then, the calculation can be made for each part as previously described in (B). Calling W the weight in pounds of steam present per hour for any one part, and L and L' the latent heats due to the pressures at the beginning and end of this part, then

$$\frac{L' - L}{L} \times W$$

will equal the number of pounds weight of steam liquefied per hour by the expansion *per se*. And this product multiplied by $L' - L$ gives the number of Fahrenheit units of heat transmuted per hour into the work of expanding the steam *per se*. The sum of the quantities obtained in this manner for all of the parts, will approximately equal the heat transmuted per hour into the work of expansion *per se* for the entire expansion.

(C) + (D) gives the total quantity of heat stricken out of existence as such, by being transmuted into the mass and molecular work done by the expanding steam between the

point of cutting off the steam in the cylinder and the end of the stroke of the piston.

(*E*) When the piston reaches the end of its stroke, the exhaust valve opens and the steam contained in the cylinder is expelled therefrom by its own expansion into the condenser, where it is instantly annihilated, so that no mass work is done by the steam on entering the condenser, the only work done being the molecular work due to the expansion *per se*.

(*F*) The number of Fahrenheit units of heat transmuted per hour into the molecular work of the expansion *per se* of the exhausting steam will be given by multiplying the weight *W* in pounds of steam in the cylinder per hour at the end of the stroke of the piston, by

$$\frac{L' - L}{L} \times L' - L$$

(L being the latent heat due to the pressure in pounds per square inch above zero in the cylinder at the end of the stroke of the piston, and L' being the latent heat due to the virtual steam pressure in pounds per square inch above zero in the condenser). The weight of steam liquefied per hour by the expansion *per se*, will be

$$W \times \frac{L' - L}{L}.$$

(*G*) If the weight of steam in the cylinder per hour at the end of the stroke of the piston, plus the weights liquefied molecularly as calculated in (*A*), (*B*), (*C*), (*D*), and (*F*), is the same as the weight of steam drawn from the boiler per hour, the cycle of operations is complete; but should it be less, then there will remain a weight of water of liquefaction in the cylinder at the end of the stroke of the piston equal to the difference between the weights of steam referred to. This water of liquefaction will be revaporized during the exhaust stroke of the piston and the steam thus evaporated will, during its expulsion from the cylinder into the condenser, by its own expansion, do molecular work at the expense of an equivalent quantity of heat.

(*H*) Calling L the latent heat of steam of the back pressure against the piston, and L' the latent heat of steam of the condenser pressure, and W the weight in pounds of the water of liquefaction revaporized in the cylinder during the exhaust stroke of the piston, the number of Fahrenheit units of heat transmuted into the work of the expansion of the steam *per se*, will be

$$W \times \frac{L' - L}{L} \times L' - L.$$

(*I*) There will additionally be abstracted from the metal of the cylinder the number of Fahrenheit units of heat required for the vaporization of the weight W of water of liquefaction under the back pressure against the piston. This will be given by multiplying W in pounds by the latent heat normal to the back pressure against the piston.

The back pressure against the piston is always greater than the pressure in the condenser, in order that there may be a flow from the former into the latter. The piston does not push out the back pressure; it increases that pressure in the cylinder so that the outflow can be produced by the expansion of the back pressure steam. The difference between the cylinder back pressure and the condenser pressure, supposing the latter constant, is regulated by the relative area of the exhaust port, reciprocating speed of piston, length and sinuosity of conduit from the exhaust port to the condenser, and pressure of the steam in the cylinder at the end of the stroke of the piston. The greater the last three and the smaller the first, the greater will be the difference between the mean back pressure against the piston, exclusive of the "cushion" pressure, and the pressure in the condenser.

The greater the pressure of the steam at the end of the stroke of the piston, the greater will be the back pressure against the piston. Now, inasmuch as with a given initial pressure, the steam will have lower and lower pressures at the end of the stroke of the piston as the measure of expansion, with which it is used, is more and more increased, and as the less pressure at the end of the stroke of the piston is

attended by a less back pressure against the piston, there can thus be realized from expansion a greater economic gain in the performance of external work than is strictly due to it. The true method of ascertaining the economy belonging to different measures of expansion, is to use the powers calculated for the mean cylinder pressures measured down to the zero line, and not the powers calculated for the indicator or net pressures.

The number of units of heat in the water of liquefaction in the cylinder at the point of cutting off the steam will be the weight in pounds of that water multiplied by the latent heat of the steam of the pressure at that point.

The number of units of heat in the injection water above the initial heat in that water, will be, after it has condensed the exhaust steam to the temperature of the feed water, the heat in the boiler steam above the heat in the feed water, minus the sum of the units of heat determined in (*A*), (*B*), (*C*), (*D*), (*F*), and (*H*); these units of heat having been absolutely striken out of existence, as such, during the processes of the steam from the boiler to the condenser.

The effect of increased reciprocating speed of piston, all other things remaining constant, is to both increase the power developed by the engine and to decrease the liquefaction of steam per stroke of piston, due to the interaction of the metal of the cylinder; the liquefactions due to all other causes remain per stroke of piston exactly the same. The liquefaction due to the interaction of the metal of the cylinder is related to *time*—the heat has to be received and delivered by the metal—the less the time the less in some ratio is this liquefaction, consequently increasing the number of strokes made by the piston per minute decreases proportionally the time of contact and correspondingly lessens this liquefaction per stroke. The liquefactions due to other causes are not affected by time.

If the steam pressure be increased, all other things remaining constant, the power developed by the engine will be increased, and the liquefaction due to the interaction of the metal of the cylinder will be decreased proportionally to power developed, because the steam temperatures in-

crease in a far less ratio than the steam pressures, and the liquefaction due to the interaction of the metal of the cylinder is wholly caused by difference of steam temperature on that metal. The liquefactions due to other causes increase in proportion to the increased pressure and, therefore, remain unaffected proportionally to power developed. The foregoing is one of the causes—and not the least—of the increased economy resulting from the use of increased pressures of steam.

When higher pressures are employed in the same engine in conjunction with the higher speeds corresponding to them, the economic gain is in the compound ratio of the two gains just described, and becomes very strongly marked.

NOTE BY THE AUTHOR.—A number of experiments with steam-jacketed cylinders have shown but little or no economic gain from the addition of the jackets, but in these cases there is great doubt whether the *nominally* steam-jacketed cylinder was *really* steam jacketed. When the jacket is in one casting with the cylinder, the cores are very difficult of removal; in fact, in such cases, they are rarely completely removed, so that what steam there may be in the jackets does not come properly in contact with the cylinder. Indeed, the cylinder is only very partially steam jacketed. As regards the cylinder heads, they, too, are very incompletely jacketed; their cores are difficult of removal also. Many steam-jacketed cylinders have very imperfect provision for promptly drawing off the water of liquefaction from the jackets, and still more imperfect are the arrangements for filling them with steam. Very rarely are the small pipes leading from the main steam pipe to the jackets sufficiently large of area to supply the jackets with steam of boiler pressure, in which case the jackets operate a loss by abstracting heat from the cylinder instead of imparting it. In all cases when experiment shows but little or no gain from the jackets, the latter should be carefully examined to ascertain whether the cores have been completely removed. Gauges should be placed on the jackets to ascertain if the full boiler pressure is in them; and, above all, the water of

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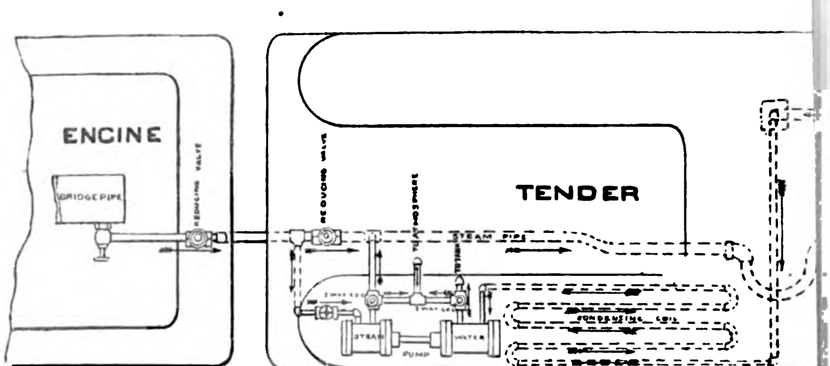

liquefaction drawn from the jackets should be measured. Where the quantity of this water is less than from six to twelve per centum of the feed water, either the cores have not been completely removed from the jackets, or the latter have not been supplied with steam of the boiler pressure, or have not been promptly drained of the water of liquefaction. Unless these important points are attended to, the experiments are worthless, as showing the inutility of steam jackets. Experiments made by competent experimenters, who take nothing for granted, but experimentally determine and verify every fact, are of the highest value; but those made by incompetent ones are worse than useless—they are misleading. The writer knows of no properly made experiments with steam jackets that did not show a considerable economy resulting from their use, and greater as the steam was used with greater measures of expansion.

STEAM HEATING OF PASSENGER TRAINS ON THE PENNSYLVANIA RAILROAD.*

Several requests have been made for a description of the passenger car steam-heating system with which the Pennsylvania Railroad has been experimenting.

Much attention has been given to the broad question of car heating by water and steam for several years, and the process of elimination has confirmed the belief on our part that the return system is the one which must finally prevail if the best results are desired; whether the arrangement which is now being applied to the cars of the Pennsylvania Railroad is the best that can be devised, can only be determined by a longer service than has yet been possible.

Briefly, a return system is one which, by the aid of a pump or other vacuum producing device, brings back to the tender of the locomotive the water of condensation derived from the steam which has given up its heat in warming the cars.

In the Pennsylvania Railroad system (see diagram), an

* From the Proceedings of the Stated Meeting of the Inst., Sept. 17, 1890.

ordinary pump is used as a means of obtaining the necessary vacuum, and is located conveniently on the inside of the tender.

The steam to supply the system is taken from the bridge pipe of the locomotive and passes into a reducing valve where the pressure is reduced to about forty pounds; it then crosses over to the tender by means of a hose pipe and enters a second reducing valve. The first of these valves is set to protect the hose pipe, the latter to protect the train from extreme pressure.

Before the steam enters this second reducing valve, a branch is taken off to drive the pump, and on the other side of the valve, the exhaust steam from the pump connects so that this steam may be turned in to heat the train.

Leaving the second reducing valve, the supply pipe runs to the back of the tender and here crosses over and connects with the main supply pipe under the car; this pipe runs the entire length of the car and connects to the next car, and so on, forming when the train is coupled up, a supply pipe running the entire length of the train.

In the centre of each car, a branch leaves the main pipe to supply the car with steam; at this point a three-way cock is placed on the main pipe and arranged so as to allow the steam to flow along the main pipe and into the branch at the same time; this is the same in all of the cars, except the last, where it is turned in such a position as to allow the steam to flow into the branch pipe only, further communication back of this on the main pipe being cut off. This cock is operated from the inside of the car and obviates the necessity of placing a cock at each end of the pipe, which cock when closed, as in the case of the rear of the last car, forms a pocket in which the condensed water may freeze; the main pipes leading through this three-way cock have a pitch to either end and are so arranged that when uncoupled they will drain themselves. This branch pipe conducts the steam to a reversing valve, which will be explained later on; by means of this the steam is distributed to both sides of the car, the two pipes convey-

ing this steam coming up through the floor on opposite sides of the car and connecting with regulating valves placed to control the heat; these two valves stand, one on either side of the aisle under the centre of the seats, and are very easily operated without disturbing passengers.

The arrangement of radiators, pipes, etc., inside the car on both sides are exactly the same, both sides being operated independently, so that in case of a leak it is only necessary to shut the steam off one side.

The regulating valve is the highest point reached, the pipes being so arranged that any condensed water that may accumulate will find its way out when the cars become uncoupled. From the regulating valve, the steam is conducted by a three-quarter inch pipe to the radiators, which are located in the corners of the car, and from them back to the centre, by means of a cast-iron radiator pipe two inches wide, four inches high, with radiating ribs one inch apart; these pipes are bolted together in lengths of about six feet.

In the centre length of the cast-iron pipe, the exit for the condensed water is placed; this is a foot lower than the regulating valve, so arranged that all the water condensed in the radiators, etc., will find its way to this point.

A piece of two-inch wrought-iron pipe, capped, is screwed into the cast-iron radiator pipe under each seat to give additional heating surface; the object is to condense as much of the steam in the radiators as possible, and this is done by throttling the exit from the cast-iron pipe. The two exits are connected with the reversing valve by two pipes which go through the floor and are brought by the reversing valve again into one pipe. The arrangement from this point is the same as in the supply pipe, namely, the pipe leaving the reversing valve connects with a three-way cock situated on the main return pipe, which runs the entire length of the car, and on the ends of which the couplings are placed, forming again when coupled a main return pipe running the length of the train; the object of the three-way cock here is the same as in the former case, and is operated from the inside of the car.

This return pipe connects with the suction end of the pump so that all of the condensed water is drawn out of the system into the return pipe, which conducts it to a condensing coil in the tank, to insure all of the steam being condensed before entering the pump; after passing through the pump it is discharged into the tank.

Reference was made some time back to a reversing valve; the conclusion that will have been drawn from the foregoing is that there are two main pipes under each car, one a supply, the other a return.

Should a car or a train be reversed, the pipes will change places; that is, instead of having the supply pipe on the left-hand side, it will be on the right-hand side; the object of the reversing valve is to obviate this difficulty, and is so arranged that by a simple movement, from inside the car, the pipe that was performing the duty of a supply will now perform the duty of a return. Another important feature of this valve is that by further movement a connection is made with the exit from the radiator pipes to the atmosphere, thereby changing the system to a direct one; the advantage of this is that in the event of the pump failing, it would be the work of a minute to set the valves for the direct steam. Again, should it be necessary to couple one of these cars to a train fitted with the direct system, it would work equally well. The couplings used are what may be termed as "male and female" and so arranged that one of the same kind is on opposite diagonal corners of the same car; the male coupling is attached to the main pipe by means of a rubber-hose pipe in the form of an "S" in a horizontal plane, which allows for all of the movements between the cars, while the female is screwed on the main pipe on the opposite side.

The male coupling has placed on it a spiral spring enclosed in a case, movable in a longitudinal direction; upon this case are placed two trunnions; the female coupling has fastened to its end a joint ring for making it tight against the end of the male coupling; upon it are also placed two trunnions which serve as the hinges for the latch. This latter consists of a forked bell-crank fulcrumed

upon the trunnions and has its short arms furnished with recesses arranged to engage with trunnions on the male coupling.

When two cars are brought together, the latches are thrown back and male and female couplings brought end to end; a movement of the latch in opposite directions causes the recesses on the short arms of the latch to engage with the trunnions on the male coupling, the two arms brought tight against each other, and in so doing, the spiral spring is compressed, which allows for small variations in length of the couplings and insures the same pressure between their faces.

The long arm of the latch is fastened by means of a chain to the platform of the car upon which the male coupling is placed, and this chain is made of such length that when the cars are uncoupled, it will pull the latch over and release the steam coupling.

The operation of the system is clearly indicated by the arrows of the diagram.

The problem of heating a train on a cold day is a simple one as compared with that of heating a train on a mild day. It will be understood that the direct system requires steam at some pressure for distribution, and so in the pipes there can never be a temperature of less than 212°.

With such a temperature on a mild day it is difficult to regulate the temperature of the cars. The Pennsylvania Railroad Company have arranged their system so that in mild weather only the exhaust steam from the pump is used; the pump creates a vacuum and this exhaust steam passes through the system in the form of a vapor, making it comparatively an easy matter to maintain the temperature at not more than 1° above the atmosphere, if necessary.

The pressure in the radiator pipes, etc., inside the cars, varies from zero to one-half pound; this latter pressure is required in the coldest weather only.

It is, therefore, obvious that in case of accident, there would be absolutely no danger from escaping steam.

The following data taken from several trains, running

part of last winter will indicate the general condition of service:

Average	pressure on supply pipe,	2·5 lbs. per sq. inch.
"	pressure in radiator pipes,	zero.
"	vacuum,	23 inches.
"	temperature outside,	32°.
"	temperature inside cars,	70°.
"	number of cars,	5.

When it is necessary to heat a train quickly, the pump is started and a pressure of twenty pounds is turned into the train pipe; this will raise the temperature 15° to 20° every five minutes.

When the car becomes warmed to the required temperature, the pressure is reduced to the normal working.

Cars when once heated are found to retain their heat for considerable time. Ten minutes before the train arrives at its destination, it is usual to shut off all the steam from the train; the pump is kept going to draw all the water out of the system, so that when the couplings are undone, there are seldom more than a few ounces of water to come out.

In connection with the heating, much care has been given to secure ventilation, and with the following simple arrangement excellent results have been obtained.

Beneath the cast-iron radiator pipes, are placed a series of air tubes, one under each seat; these make a connection with the outside air through a two-inch opening. The hot air rising from the radiator pipes naturally draws the fresh air in from these tubes, which becomes heated, and rising up passes out through the deck ventilators inducing a current of warm, fresh air, which is made to pass through the car at all times.

An experiment was made with a train of twelve cars, and most favorable results were obtained, clearly demonstrating that the system is quite capable of heating any train running, or that would be likely to run.

In the return system, the steam taken from the boiler does not seem to affect the steaming of the locomotive; considerable trouble has been experienced in this respect, when using the direct system with heavy trains.

During the winter of 1889–90, seventy cars were put in use and performed satisfactory service.

There are a number of constructive details of the system described which can undoubtedly be simplified, as more experience is gained from actual operation.

THEO. N. ELY.

Altoona, September 15, 1890.

ON THE FORCE OF IMPACT OF WAVES AND THE STABILITY OF THE SUPERSTRUCTURE OF BREAKWATERS.

BY L. D'AURIA.

Great difficulty has always been experienced in determining the safe limits of construction for marine works subjected to the action of breaking waves, on account of the ignorance prevailing in regard to the magnitude of the force of impact of such waves. One of the greatest marine engineers, Smeaton, we are told, used to refer to such force as one being *subject to no calculation;* while, others, like Sir Samuel Brown, Captain Taylor and Minard, estimated it as being equivalent to a pressure from seventy pounds to 144 pounds per square foot. These estimates, however, were shown to be a mere bagatelle by the results obtained with marine dynamometers, but even these results fail to account for the destructive power of breaking waves, for no one would at present dare to proportion the dimensions of the superstructure of a breakwater to the observed pressure reported by the dynamometer.

From this brief sketch of the status of our knowledge regarding the force of impact of breaking waves, it may be readily appreciated how important it is to determine the highest limit to which such force, under favorable circumstances, may reach, by an exact method based upon a well-grounded scientific principle, and this is what has been aimed at in the following pages.

The amount of energy which is necessary to cause the propagation of a wave is equal to the energy which such

wave would require if it had to be moved *en masse* with its velocity of propagation upon a frictionless level-surface.

Denoting by s the full length of the wave; by k its height measured from crest to trough; by γ the weight of one cubic foot of sea-water; by g the acceleration of gravity, and by v the velocity of propagation, the amount of energy represented by one linear foot of such wave can be expressed approximately by

$$E = \frac{s\,k\,\gamma\,v^2}{4g}$$

This energy, when the wave breaks under favorable conditions, may be wholly discharged against every linear foot of the superstructure of a breakwater during the interval of time (s/v) which the wave requires to propagate its own length. Therefore, if f represents the mean force of impact of the wave per linear foot of superstructure during such time, we can write the equation

$$E = f\,v \times \frac{s}{v};$$

which gives

$$E = \frac{\gamma\,k\,v^2}{4\,g}.$$

Since we know that in the beginning the force of impact is zero, we may express the maximum force of impact by twice the mean; or,

$$F = \frac{\gamma\,k\,v^2}{2\,g} \qquad (1)$$

This force may be considerably reduced when the impact is oblique, but the obliquity of the impact cannot be always relied upon. In fact, quoting from Harcourt, Harbours and Docks, we have the following opinion in regard to the obliquity of the impact:

"Though the angle of incidence as to exposure may be oblique, in practice this obliquity must always be more or less modified by the tendency for the waves to finally fall upon the shore on lines parallel with the coast line."

Therefore, it would not be safe to discount from the

value of F given by (1) in proportioning the dimensions of the cross-section of the superstructure of a breakwater, even when the impact may seem to be oblique.

Now, let H represent the height of the low-water line above the bottom plane of the superstructure; R, the range of tide; h, the elevation of the tops of the superstructure above the plane of high water, and x, the width of the cross-section, supposed rectangular. The height of the centre of impact above the bottom plane of the superstructure is a maximum at high water, and may be safely put equal to $(H + R)$. Denoting, then, by γ, the weight of one cubic foot of superstructure, the buoyancy being taken into account, we can form the equation of moments

$$\frac{1}{2} x^2 \gamma_1 (H + R + h) = \frac{1}{2} \gamma \frac{k v^2}{g} (H + R);$$

from which we derive

$$x = v \sqrt{\frac{\gamma k (H + R)}{\gamma_1 g (H + R + h)}} \tag{2}$$

This gives the width of the cross-section of the superstructure to resist overturning.

If we denote by μ the coëfficient of friction of the superstructure upon its bed, the condition to prevent sliding will be

$$x \gamma_1 (H + R + h) \mu = \frac{\gamma k v^2}{2 g};$$

from which we derive another value of x which, to avoid confusion, will be indicated by

$$x_1 = \frac{\gamma k v^2}{2 \gamma_1 g \ \mu (H + R + h)} \tag{3}$$

From the experiments on friction of large stones or blocks made by Thomas Stevenson, F.R.S.E., F.G.S., the value of μ varies from 0·65 to 0·79. But taking into account the tremor of the superstructure caused by wind and waves, it will be safer to assume $\mu = 0·5$, and write

$$x_1 = \frac{\gamma k v^2}{\gamma_1 g \ (H + R + h)} \tag{4}$$

Hence, we have the following simple relation

$$x_1 = \frac{x^2}{H + R} \tag{5}$$

in which x is the value offered by (2).

This relation shows that the same width of cross-section, which is sufficient to balance overturning, may not be sufficient to prevent sliding, or *vice-versa*. When we find $x_1 < x$, it is plain that the safe value is x; and when we find $x_1 > x$, it is equally plain that the safe value is x_1. By pursuing this practice, we provide against sliding and against overturning at the same time.

Of course, a coëfficient for safety ought to be applied in determining the values of x and x_1, but this we leave to the discretion of the engineer, and shall now proceed to a test of our formulæ.

In the year 1883, the superstructure of the breakwater built in the Oswego Harbor, N. Y., was set back by the force of the waves during a gale to the extent of three feet at one particular point. The superstructure consists of cribs whose net weight per linear foot is estimated to be about 65,000 pounds. The elevation of the superstructure above the level of the water is about twelve feet, which we have to use instead of k, since the waves were much higher than twelve feet. The velocity of propagation of the waves was observed to be between thirty and forty miles per hour, or between forty-four and fifty-nine feet per second. Taking the higher limit, our equation (1) furnishes

$$F = 40{,}500 \text{ pounds,}$$

and consequently the coëfficient of friction is found to be $\mu = 0{\cdot}62$, which is almost identical with the lowest value of μ determined by Stevenson's experiments.

With such close agreement there cannot be any doubt left as to the soundness of the formulæ given above and of the principles involved.

A REVOLUTION IN DYEING.

BY PROF. R. L. CHASE,
Pennsylvania Museum and School of Industrial Art.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *January 13, 1890.*]

The Lecturer was introduced by Prof. PERSIFOR FRAZER of the INSTITUTE, and spoke as follows:

MEMBERS OF THE INSTITUTE AND LADIES AND GENTLEMEN:

In considering this subject, I desire to appeal to the eye as well as to the ear, and by referring to the dyed sample sheets,* hope to show clearly the condition of the dyeing industry at the present time, compared to what it was previous to the discovery of the artificial coal-tar dyestuffs. The dyeing industry has undergone some remarkable changes in the past thirty-three years, but these have come so gradually, first one discovery and then another that it is only by looking at the subject as a whole that we are able to see how great a revolution has been wrought.

Before taking up the subject proper it will be necessary to consider briefly some of the general methods used for dyeing different fabrics. Comparing wool and cotton, a great difference is noticed in the readiness with which they become colored when treated with different dyestuffs. There are a large number of the artificial as well as some of the natural dyestuffs which will color wool directly, the addition of an acid being in many cases necessary for the full development of the tinctorial power, while cotton, when similarly treated, acquires only a feeble stain. This is clearly seen in the samples dyed with methyl, violet and indigo extract. In each case the wool is deeply-colored while the cotton is but barely tinted or stained. A number

* The lecture was illustrated by some 300 dyed samples, representing most of the dyestuffs in ordinary use as well as a number that have not yet come into general use.—R. L. C.

of these dyestuffs can be used, however, for coloring cotton that has been previously mordanted, as will be seen later on. Solutions of all this class of dyestuffs are strongly colored and impart the same to the wool, and as they can produce but one color, varying simply in intensity, they are sometimes spoken of as monogenetic coloring bodies.

A second class of dyestuffs, to which nearly all the natural, as well as a few of the artificial dyestuffs belong, will dye neither wool nor cotton without the aid of a mordant. This is shown in the samples dyed with alizarine paste, and with logwood extract. Usually the fibre is mordanted first, and then on immersion in a solution of the dyestuff a color is produced depending on the mordant as well as on the dyestuff. So that by the use of different mordants, one dyestuff can be made to produce a number of very different colors, and for this reason these are sometimes spoken of as polygenetic coloring bodies. Their solutions in many cases possess little color, but they each contain matter which will unite with metallic salts to form pigments, and the proper formation of these on the fibre is the object of the dyer.

The process of mordanting in the case of wool is quite simple, as it is only necessary to boil the wool in a dilute solution of the desired metallic salt, usually with the addition of some acid salt, as cream of tartar, to prevent too rapid decomposition. Salts of chromium, aluminium, iron and tin are those most used, while a few others meet with an occasional application. The use of bi-chromate of potash, however, exceeds by far all the rest, and it is one of the most useful mordants we possess. In the case of cotton the methods of mordanting are far more complex, and various expedients are resorted to, some of which will be mentioned later on.

A third class of dyestuffs comprises those which will dye either wool or cotton directly. Up to within a few years there were but few representatives of this class among the artificial dyestuffs. At the present time, however, there is a very large and constantly increasing number belonging to the so-called "benzidine dyestuffs."

THE NATURAL DYESTUFFS.

While as a rule these belong to the second class, and require a mordant for the full development of their coloring matter, yet there are a few exceptions to this, and the first we will consider is remarkable from the fact that it will dye unmordanted cotton as well as wool. It is in fact the only natural substantive dyestuff for cotton of practical importance.

TURMERIC.

This consists of the tuber of the *Curcuma tinctoria*, and it comes to the dyer in the form of fine powder. As stated above it will dye both cotton and wool directly, and a comparison of the two fibres dyed in one bath at the same time is shown. It can also be dyed on mordanted wool, and a comparison of three samples is made.

The first was dyed in an acid bath on unmordanted wool, the second on wool prepared with alum and cream of tartar, and the third on wool prepared with bichromate of potash. Although very cheap, and fine yellow colors can be obtained with this dyestuff, yet the shades are all very fugitive to light, and are also changed by soap so that it would be better for the consumer of the dyed goods if it were never used at all.

QUERCITRON BARK AND FLAVINE.

These are of especial interest to us, as the bark is obtained from a species of oak growing quite extensively here in Pennsylvania, as also in some of the other States. Flavine is a preparation of the bark, and is much stronger and purer than the bark itself. It has had a very extensive use in dyeing wool, and produces yellows, which are quite fast to both light and soap. It is usually dyed with alum and stannous chloride, with the addition of some acid salt. The dyestuff and mordants are all put in together, and the wool entered and the bath gradually heated. By proper regulation of the mordants and the heat the shade can be modified greatly, so that it is possible to obtain pure yellow shades or reddish yellows as desired. It can

also be dyed on wool mordanted as usual, and a comparison of the shades thus produced is shown. The first having been prepared with alum and cream of tartar, the second with bichromate of potash, and the third dyed in one bath with alum, oxalic acid and tin crystals.

FUSTIC.

This dyestuff is obtained from the wood of the *Morus tinctoria*. It comes to the dyer in the form of chips; also coarsely ground and as an extract. It is very extensively used at the present time, and is one of the few natural dyestuffs which, so far, has been but little affected by the artificial products. In dyeing fast shades on wool, it is the yellow producing dyestuff almost exclusively used. It is of so much importance that four dyed samples are shown, as follows: First, on unmordanted wool, where it is seen to produce only a stain, but, in some cases, this has been made use of in producing light cream shades, the coloring matter sometimes being added to the scouring bath itself; second, on wool prepared with alum and tartar, while the third was dyed on unmordanted wool with alum in the bath, and is seen to be much better than the first. The last one was dyed in the usual way on chromed wool, and is the method most used. The shades produced by this latter method are very fast to both light and soap, and as they are quite inexpensive, fustic is at once seen to be very useful in dyeing.

OTHER YELLOW DYESTUFFS.

Besides the three already mentioned, there are also a number of other yellow dyestuffs which are, however, of much less importance. These are Persian berries, carberry, young fustic and weld. These are only used to a limited extent. With the exception of weld, they all yield shades which are fugitive.

RED COLORING SUBSTANCES.

There are two classes of red dyestuffs, the first comprising those whose coloring matter is easily soluble in water, while the second includes those whose coloring matter is so

insoluble that it cannot be dissolved and sold in the form of an extract, but has to be used in the form of a very fine powder.

The first class comprises a number of red woods of the species *Cæsalpinia*, all being very similar in their properties and among the best known of which are Brazil wood, peachwood, sapan wood, Lima wood, Bahia wood, etc. They all seem to possess the same coloring matter, Brazilian ($C_{16}H_{14}O_5$) which, when oxidized, gives rise to brazileïn ($C_{16}H_{12}O_5$). The chemical constitution of the coloring matter of most of these natural dyestuffs is not very well known, although the subject is receiving considerable attention at the present time. Some suppose that the symbol of the above is $C_{22}H_{18}O_7$, and that it may possibly be a resorcinol ether of hæmatoxylin, with the constitution

$$C_6H_4\begin{cases}OH\\ O\ C_{16}H_{13}O_5\end{cases}$$

The coloring matter of this class of dye-woods is often extracted and sold as hypernic extract. Taking Lima wood as a representative, let us see what shades are produced. On unmordanted wool a dull red stain is formed, while with alumina, as the mordant, a heavier but dull red is obtained, and on chromed wool a very fine purple results. Unfortunately, however, these shades are very fugitive, and it would be better if none of these woods were used. Second, or *insoluble class* of *red dye-woods.*

These are obtained from a different species than the previous class, and the three principal representatives are camwood, barwood, and sanders or santal wood. They are very similar in their dyeing properties and the shades produced are very much alike, that produced with sanders having a yellower shade than that derived from camwood, which latter is stronger and yields the bluest shades of the three. On account of the insolubility of their coloring matter, it is necessary to add the ground wood directly to the bath, and for this reason their use is confined to smooth face cloths, such that the little particles of dyestuff will not stick to them, but can be readily removed by washing. The shades

produced are quite fast, and were it not for this trouble with their insolubility they would have received a much more extensive use than has heretofore been the case. At the present time, however, the use of all these natural red woods is being rapidly superseded by artificial alizarine.

On unmordanted wool, these dyewoods give quite heavy shades so that they are well suited to what is known as the "stuffing and saddening" method of dyeing, in which the wool is first boiled with the dyestuffs and then the mordants added to the same bath.

In the samples shown, one is dyed with red sanders alone, while two samples of camwood—one dyed on wool prepared with alum, and the other with bichromate of potash—are compared with two similar samples dyed with sanders. It is easily seen that, while each produces a dark reddish brown shade, yet that produced with the camwood is of a bluer cast.

Efforts have been made to form a soluble compound by treating the santalin or coloring matter of these woods with sulphuric acid, forming a sulphonic acid. This has been successfully accomplished, and the product obtained is said to dye wool in an acid bath and to produce very fast shades. At the present time, it is impossible to say whether this will meet with commercial success or not.

ARCHIL AND CUDBEAR.

These are obtained from lichens, and are very similar in their dyeing properties and in the shades they produce. Archil comes in the form of an extract, while cudbear is a dry powder. They differ from the dyestuffs we have been considering, in that they are monogenetic and are usually dyed on unmordanted wool, in an acid bath. They have been very extensively used in connection with the artificial dyestuffs for compound shades. When we consider their cost compared with the depth of color produced, it is seen that they are very expensive to use, and at the present time there is a great demand for some artificial dyestuff that will dye as easily and more cheaply. There are a large number of these archil substitutes now sold, and no doubt the

day is not far distant when archil and cudbear will be displaced entirely by some of these substitutes. As the shades produced with archil or cudbear are not fast, it will be no loss to the public.

MADDER.

Madder is the ground root of the *Rubia tinctorum*, and until the discovery of artificial alizarine was a very important dyestuff for both wool and cotton. The plant was cultivated very extensively in Europe, and gave employment to a great many persons. The discovery of artificial alizarine destroyed this industry and built up that of the manufacture of the artificial substitute. The shades produced with madder are very similar to those produced with the commercial alizarine, with the exception that the shades on wool are yellower and duller. Three dyed samples are shown, two of which are on wool mordanted as in the previous cases, one with alum, and the other with "chrome." The third being dyed in one bath with tin crystals and cream of tartar.

This will be considered more at length under artificial alizarine, and as madder has now been almost entirely superseded by the artificial product, we will pass on to another red dyestuff.

COCHINEAL.

Cochineal is the dried insect *Coccus cacti*, and is therefore different from any of the dyestuffs so far considered. The insect was formerly extensively cultivated in Mexico, and proved a flourishing industry for many years until artificial scarlet dyes were discovered, which were cheaper and even faster than the shades produced with cochineal. Cochineal is dyed on wool in a similar manner to flavine. using one bath. Two shades are shown, one somewhat bluer than the other. The first was dyed with oxalic acid and tin crystals, while the second had alum in the bath, producing a bluer shade. At the present time, but very little cochineal is used, and especially so in this part of the country. Some maintain that the cochineal scarlets are superior and insist on this method of dyeing, but cases are not unknown in which

the azo scarlets have been used while the price paid was for cochineal scarlet. There is but little doubt that in a few years cochineal will be another of the natural dyestuffs that has been entirely superseded by the artificial products.

LOGWOOD.

This very important dyewood consists of the wood of the hæmatoxylon, growing in tropical climates. This and fustic are now the two principal natural dyestuffs which have not as yet been very seriously replaced by the artificial products, although, as we shall see later on, there are quite a number of artificial black dyestuffs which are infringing on the logwood blacks and may in time prove serious competitors. Logwood comes to the dyer in a similar manner as fustic, and we have the chips, ground wood and extract. It is used very extensively for blacks which are produced on wool mordanted with bichromate of potash. If an insufficiency of logwood is used a blue or blue-black is produced, and therefore a small amount of fustic is added with the logwood in order to overcome this tendency and produce a dead or jet black. If dyed properly, the black is fast to both light and soap, but unless properly performed, there is a tendency to turn greenish by prolonged exposure.

When dyed on wool mordanted with alum, very fine purple shades can be obtained, but unfortunately these are not fast. This shows us clearly that in order to obtain fast shades the mordant is of as much importance as the dyestuff. Logwood is also quite extensively used for blacks on cotton as well as for many other shades in connection with other dyestuffs.

INDIGO.

This coloring matter is obtained from the leaves of various species of Indigofera, which is largely cultivated in India. It is a very valuable as well as important dyestuff, and is extensively used for both wool and cotton dyeing. As indigo is insoluble in water the method of dyeing is peculiar. The coloring matter of indigo is indigotin ($C_{16}H_{10}N_2O_2$), and by the action of reducing agents in the presence of an alkali the indigotin is reduced to the form of

white indigo ($C_{16}H_{12}N_2O_2$), which is soluble in alkaline solutions. If either cotton or wool is immersed in such a bath, the white indigo is absorbed by the fibre, and on removal from the bath and exposure to the air, this is oxidized to indigotin and precipitated right in the fibre. The shades produced are very fast, and indigo-dyed goods bear a high reputation. From the method of dyeing, it is easily seen that the dye cannot penetrate the fabric as thoroughly as in other methods, and for this reason indigo-dyed cloth does not always wear well at the seams, and also the color is liable to crock or rub off. If dyed in the form of stock, however, the fibre has a better opportunity to become thoroughly penetrated, and both dangers are lessened. Dyeing with indigo is quite expensive, and also requires much practice in order to obtain good results, and a substitute for it is very desirable, provided the substitute will produce shades equally as fast and at a cost not exceeding that of indigo. Although this has not yet been accomplished, yet there are several competitors to indigo which may some day displace it. These will be spoken of later on under the artificial dyestuffs.

INDIGO EXTRACT.

Another method of dyeing with indigo is to convert it into a soluble form by treatment with sulphuric acid, whereby a sulphonated compound is formed which is soluble in water and will dye unmordanted wool in an acid bath a very fine blue. Unfortunately, however, the shades thus produced differ entirely from those produced in the vat method, and are neither fast to light nor soap.

The sulphonated compound comes into use in the form of indigo extract, and is used in enormous quantities in dyeing in connection with the acid coal-tar dyestuffs.

CATECHU.

This is obtained from certain species of the *Acacia*, growing in India. It is very extensively used for dyeing cotton, and alone produces a brown shade. The cotton is boiled in the dyestuff and is then run into a second bath containing bichromate of potash, which develops the shade. Cotton,

thus prepared, can be dyed with most of the woods already mentioned, and also with those artificial products known as the basic aniline dyestuffs. So that catechu is not only a coloring substance in itself, but also serves as a mordant for other dyestuffs. It is much used for this purpose, and a large number of the samples of cotton shown are thus dyed. It has the tendency to leave the cotton harsh, which is quite an objection. It has also quite strong competitors in some of the newer artificial dyestuffs, and were it not that catechu is so cheap, no doubt it would soon be replaced, and even as it is, there is a tendency to discard it wherever possible and to use dyestuffs that will leave the fibre in a better condition.

DISADVANTAGES IN THEIR USE.

For compound shades the use of the natural dyestuffs is attended with some difficulties due to the different ways in which they are dyed. By the combination of the three primary colors, blue, yellow and red, all shades are possible, so that by the use of dyestuffs which will produce these individual colors all compound shades can be dyed. For fast shades on wool, we have red and yellow dyestuffs which are dyed similarly and can be mixed in all proportions, but when a blue color is also necessary, as is the case with the majority of the compound shades, there is no suitable dyestuff that can be mixed with the other two. This makes it necessary to go through at least two dyeing operations, the wool being dyed blue in the indigo vat while the other dyestuffs are applied in a separate bath. Besides the extra work attendant on this method, there is more danger of injuring the wool from overworking; and, also, it is very difficult to match shades closely, for unless the "bottom" is of just the right depth it is impossible to produce the desired shade.

When fast shades are not required there is not so much trouble, for in turmeric, indigo extract, archil or cudbear we have the required yellow, blue and red dyestuffs, each of which will dye wool in an acid bath and can be mixed in all proportions.

Cotton dyeing presents similar difficulties, and while most brilliant and permanent reds can be produced with madder and blues with indigo, yet as they are dyed in an entirely different manner, it is impossible to combine the two together. The other dyestuffs are used in still different ways, but can usually be combined for "topping" cotton prepared with sumac and copperas or with cutch and bichromate of potash, but the shades thus produced are all very dull, and, in fact, there are but few bright shades that can be produced by the use of the natural dyestuffs. So that for bright colors it is usually necessary to resort to the artificial coal-tar dyestuffs, which we will now consider.

THE ARTIFICIAL COAL-TAR DYESTUFFS.

Previous to 1856, all dyeing was done with the natural coloring substances just described, but in that year a discovery was made that has led to an inexhaustible mine of dyestuffs, producing every shade of color imaginable, and many of them of a brilliancy and beauty never before deemed possible. As we stand here and look back on the discoveries of the past thirty-three years in this field, it seems almost incredible that so much progress could be made in such a short time, and that there are now living those engaged in the dyeing industry who have followed these changes from the very first. In 1856, the science of organic chemistry was in its infancy and up to that time, there being no especial pecuniary advantages to be derived from its study, there was but little prospect of much advance in the subject. The discovery of the artificial dyestuffs with their commercial importance changed this entirely and has led to great advancement in our knowledge of the constitution of organic compounds. So that while the dyeing industry is greatly indebted to the organic chemist for the multiplicity of dyestuffs furnished him, yet on the other hand organic chemistry is under obligations to the dyeing industry for the emoluments which have rendered the study possible to so many persons.

FIRST ARTIFICIAL DYESTUFF OF COMMERCIAL IMPORTANCE.

The manufacture of natural organic compounds of commercial importance has always proven a problem of the

greatest interest to the organic chemist. Not only is there the pecuniary advantage to be considered, but also the honor of supplying to humanity a needed compound at a lower cost and in larger quantities. Quinine is one of these compounds that has proven of especial interest, and it was while endeavoring to manufacture this drug artificially that an English chemist, named Perkins, accidentally succeeded in making a coloring matter to which the name mauve, aniline violet, or Perkins' violet was given. It proved to be the first commercial dye from aniline, and, although it was soon superseded by other dyestuffs, and is not now used at all, yet it has a great interest as the progenitor of a great family. As it was derived from aniline, as also a number of the earlier discovered dyestuffs, the general name of the "aniline dyestuffs" was given to them and has remained in common parlance to this day for all the artificial dyestuffs; but, as we shall see, a large number are not derived from aniline but from other substances derived from coal-tar, and as all, with a very few exceptions, are derived from this, a better name is the artificial coal-tar dyestuffs. This being the case, it is at once seen that these dyestuffs were not possible until the introduction of coal gas, so that the two bear a very close relationship. In the manufacture of coal gas, besides the gas itself, there are a number of other products known collectively as coal-tar. This consists of a large number of substances known as hydrocarbons, some of which are liquids, while others are solids dissolved in the liquid portion. By distillation the different products are separated in a more or less pure condition and used in the manufacture of the artificial dyestuffs. The principal products thus used are benzene, toluene, xylene, naphthalene, anthracene. From the first two, by nitrification and subsequent reduction, the commercial aniline oil is obtained and from it, either directly or indirectly, a large number of dyestuffs have been made.

ANILINE RED OR MAGENTA.

The discovery of mauve was soon followed by that of another dyestuff, to which the name aniline red or magenta was given. There are a large number of ways of making

this, but they are based on the same principle, *i.e.*, oxidation of commercial aniline oil. In 1859, this dyestuff was manufactured on a commercial scale, and its manufacture has continued to the present day, large quantities being manufactured in this country and indeed in some cases proving the principal product. At first it was largely used for wool dyeing but at the present time its use is confined almost exclusively to cotton, for which it is used in large quantities. It is the first of a series of dyestuffs known as the "basic aniline dyestuffs," all of which bear a close relationship to it in their constitution and behave very similarly in dyeing.

The discovery of aniline red was closely followed by that of blue, violet and green dyestuffs.

If we look at the constitution of rosaniline, the base of aniline red, it is seen that there are three amido groups (NH_2) and each of the hydrogen atoms in these can be replaced by various organic radicals giving rise to dyestuffs of different kinds. If the replacement is by ethyl (C_2H_5) or methyl (CH_3) or benzyl (C_7H_7) groups, violet dyestuffs are produced, the first giving the reddest shades and the latter the bluest shades of violet.

The introduction of phenyl (C_6H_5), on the other hand, gives rise to the blue dyestuffs. One phenyl group giving rise to very red or violet shades, and the greater the number introduced the bluer the shade.

BLUE DYESTUFFS.

By heating rosaniline or one of its salts with pure aniline oil and a little benzoic acid, blue coloring matters are obtained which are insoluble in water but are soluble in alcohol and are therefore known as spirit blues. On account of their insolubility, great trouble was experienced in dyeing with these blues. The knowledge that indigo could be converted into a soluble compound by treatment with sulphuric acid, led to experiments on this blue and in 1862, Nicholson succeeded in forming a soluble compound, which received the name of Nicholson's blue. Three different compounds are made in practice, depending on the number of sulpho

groups that enter into the compound. These are known as alkali blue, soluble blue and cotton blue. The first being used entirely for wool and the latter entirely for cotton. Similar to the case of indigo these sulphonated compounds produce shades which are not fast, while the "spirit blue" produces quite fast colors. Both the alkali and cotton blues are still used largely and are both manufactured in considerable quantities in this country.

VIOLET DYESTUFFS.

The first violet dyestuff was a "spirit violet," which was made in the same way as the blues above mentioned, only using a less amount of aniline and in that way introducing one or two phenyl groups. This was soon displaced by Hoffman's violets, which possessed the great advantage of being soluble in water. They were made by treating rosaniline or magenta with methyl or ethyl iodide. These, however, were expensive and have now been replaced by the methyl violets, which are much cheaper and also very easily made. Di-methyl aniline is treated with copper sulphate and ordinary salt and the violet color immediately commences to show throughout the mass. This is extracted and converted into a salt of chlorhydric acid to render it soluble, and on being dried and ground is ready for the market. By the action of carbon oxychloride on di-methyl aniline another methyl group can be introduced giving rise to a much bluer shade of violet. Also by treating the methyl violets with benzyl chloride ($C_6H_5CH_2Cl$) in an alcoholic solution with soda, the benzyl group enters into the compound and gives rise to the bluest shades. These violets dye in a similar manner to magenta and are mostly used for cotton. On unmordanted cotton only a stain is produced as was seen on the first sheet of dyed samples shown, while cotton mordanted with sumac and some metallic salt, as tartar emetic, and then immersed in a solution of the dyestuff becomes deeply colored.

Since 1883 the number of violet dyestuffs has been increased by the manufacture of dyestuffs by the Badische Anilin-und Sodafabrik and also by the Gesellschaft für

chemische Industrie, in which six organic radicals have been introduced instead of five as in the ordinary methyl violets. By using Fisher's acid chloride process they have made both the hexa methyl and ethyl compounds, as also the mixed compound tri-methyl tri-phenyl pararosaniline. This last being also manufactured by the Farbwerke.

[*To be continued.*]

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE

[*Stated Meeting, held at the Institute, Tuesday, October 21, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, October 21, 1890.

Mr. H. Pemberton, Jr., in the Chair.

Members present: Messrs. Wahl, Smith, Hooker, Hall, Sadtler, Haines, Frankel, Tuttle, Williams, Galt, Jayne, and a number of visitors.

Dr. Wahl presented a paper, by Dr. Hans von Strombeck, on "The Constants of Ammonia," and proposed its reference to a committee for examination with a view to its publication.

The Chair appointed Messrs. Rowland, Wahl and Hall as the committee.

Prof. Sadtler presented and made some remarks in regard to a paper on "Utah Ozokerite." Specimens were exhibited to the Section. The material was said to be obtained in quantities. Prof. Sadtler spoke of some of the uses of ozokerite obtained from Hungary.

Prof. Smith read a paper giving some of the results of a preliminary study by Dr. Keller and himself on the action of sulphydric acid on certain amines.

The paper was referred for publication.

Adjourned. H. W. JAYNE, *Secretary pro tem.*

ON THE USE OF GALVANIZED IRON FOR ARTESIAN WELLS AND FOR THE CONVEYANCE OF DRINKING WATER.

BY REUBEN HAINES.

[*Read before the Chemical Section. September 16, 1890.*]

The writer recently received for analysis for potability a sample of water from an artesian well, which proved to be of somewhat unusual character. The well had been sunk a few months ago on a homestead property, situated a short distance beyond the northern boundary of this city. It was seventy-eight feet in depth, and the outer casing as well as the inner tube were of galvanized iron.

The water had been previously analyzed by another chemist and was pronounced by him to be contaminated with sewage. As no source of contamination was known to exist near the well, it was thought a mistake had been made.

My analysis showed, however, that water contained an enormous amount of free ammonia, and also an extraordinarily large amount of zinc in actual solution.

I subsequently learned that the pipes were discovered to be very much corroded in the short time they had been in use.

The following are the results of my examination of the water:

Composition—

	Parts per 100,000.
Free ammonia,	0·4730
Albuminoid ammonia,	0·0080
Chlorine,	0·80
Total solid matter at 100° C.,	15·50

Nitric Acid, { Only faint traces by the acid phenyl sulphate test in 100 cc. in column seven inches in height in a colorless glass tube.

Sulphuric Acid (qualitative).—Small traces or none at all.

Injurious Metals, { Large amount of zinc in solution; identified by several appropriate tests.

Appearance.—Clear and colorless, there being no turbidity, no sediment deposited until exposed to the air for several days, when white flakes were observed at the bottom of the bottle.

Taste.—After-taste, very slightly astringent.

I subsequently determined the amount of the zinc in the remaining portion of the same sample, and found it contained 3·9 grains of the oxide of zinc per gallon, equivalent to 3·12 grains of metallic zinc. As this portion of the water was small, only one-quarter liter, I was unable to make a complete analysis, but in the following statement have supplied by calculation the amounts of sodium and carbonic acid, assuming that all the chlorine was combined with sodium only, and that zinc calcium and ammonia existed wholly as carbonates; the small traces of sulphuric acid, nitric acid and magnesia, if present, being neglected altogether. This, I think, must be at least approximately correct, as the evaporated solids yielded considerable carbonic acid on treatment with HCl. The results are as follows:

	Grains per Gallon.
SiO_2, Al_2O_3, and Fe_2O_3,	0·85
NaCl,	0·77
$CaCO_3$,	1·30
$(NH_4)_2CO_3$,	1·25
$ZnCO_3$,	6·52
Total solids,	10·69

The total solids by actual weight in this portion were equivalent to 10·56 grains per gallon dried at 100° C.

In the above analysis it will be observed that the free ammonia is the only positive evidence of organic contamination in this water. The albuminoid ammonia, however, while scarcely excessive for a medium quality and usable surface-well water, seems rather too large for a deep well in the rock. The albuminoid ammonia should not exceed 0·0050 parts per 100,000, and is frequently not more than 0·0030, if the water is absolutely secure from contamination. The amount of chlorine is not more than is natural for many pure and soft well waters. The freedom from nitrates is rather remarkable, there being less than is found in some of the purest spring waters.

I ascertained that there was no cesspool drain, manure heap, or any other source of contamination within 200 feet of this well. At that distance there is a stable, but the stalls are drained by a cemented terra-cotta pipe, which is carried to a considerable distance further away from the well. As regards surface drainage, the well is favorably situated, being on higher ground than the stable. The nearest source of contamination on the adjoining premises is at least 500 or 600 feet distant.

In every respect, therefore, so far as known, the well appears to be properly protected as regards location. As, however, the well is deep and the amount of water abundant, it is reasonable to conclude that a water-bearing stratum draining a very large area, or perhaps a strong flowing underground stream has been tapped. Hence, the water may have become contaminated by sewage at a very great distance from the well. Such instances have been known to occur. In this way I am inclined to account for the free ammonia in this water, which has possibly been increased by reduction of nitrates previously present in the water, induced by contact with iron and zinc.

There can be no doubt that the water has been, somewhere in its course, contaminated with a large amount of nitrogenous organic matter, probably animal sewage.

A peculiar feature of this water is the large amount of zinc which it contains, and the fact that the whole of it is in solution. On heating or partial evaporation, the zinc separates as a film on the surface of the water.

That water has a solvent action upon metallic zinc has been known for a long time. As early as 1778 it was alluded to by M. de la Falie, a French physician and chemist. Thenard and Gay Lussac and, in 1813, Vauquelin and Deyeux reported upon it to the French Academy of Sciences. Chauffèle, in 1848, and Payen and Chevallier, in 1854, confirmed it experimentally as regards ordinary water and even distilled water. Similar results have been reported by others since that time. In most of these cases, only traces or very small amounts of zinc were dissolved. Prof. W. R. Nichols, of Boston, some

fifteen years ago, stated that he always expected to find zinc in water which passed through galvanized iron pipe. He found that Lake Cochituate water, which had remained undisturbed in pipes at the Massachusetts Institute of Technology for thirty-six hours, the pipes having been in use for eight or nine years, contained a small amount of zinc in suspension, and 0·062 grain per gallon in solution.

In another case, when the analysis of the water gave suspicious evidence of contamination with sewage, he found a trace of zinc in suspension, and 0·843 grain per gallon in solution.

The mode of action of common potable water on zinc is understood to be, first, the formation on the surface of the metal of a coating of oxide of zinc, which is then acted upon by the carbonic acid generally present in the water, converting it into a mixture of oxide, carbonate and, according to Pettenkoffer, an oxyhydrocarbonate, or as now termed, hydrated basic carbonate, which gradually becomes more or less separated from the metallic surface and is carried in suspension or forms a film on the surface of the water, while a small part dissolves.

In the case before us, I think the oxide and carbonate of zinc have combined with the carbonate of ammonia to form the double carbonate of zinc and ammonia, which is insoluble in water, but very soluble in carbonate of ammonia, the excess of carbonate of ammonia in the water thus holding it in solution. This combination of salts is decomposed by boiling water or by heating on the water bath.

I found that both commercial zinc and chemically pure zinc, each in the coarsely "granulated" or feathered condition, were rapidly acted upon by a cold dilute solution of carbonate of ammonia, from which, after twenty-four hours' contact with zinc, a copious precipitate of zinc sulphide was thrown down by H_2S after acidifying with acetic acid.

It is not unusual to find considerable zinc in suspension either as hydrated oxide or carbonate in waters, for instance, that have been retained for some time in galvanized iron, "circulating boilers" in dwellings, especially in the case of new boilers.

I once had in my possession a piece of lead pipe which had connected a "circulating boiler" to the "water-back" of the kitchen range, and which at one point was almost completely stopped up with a reddish-white deposit; and this deposit proved to be composed principally of oxide and carbonate of zinc, derived, no doubt, from the galvanized iron boiler.

I have also observed in one instance a scum or film of zinc hydrocarbonate almost completely covering the surface of the water in a cedar tank after the water had entered this tank through several hundred feet of galvanized iron pipe leading from a spring-house. The spring water had been until near that time quite pure, but was contaminated during heavy rains by a shallow well a few feet distant, which contained decaying vegetable matter and the water of which yielded a large amount of free ammonia, but gave no evidence of sewage pollution.

There can be no doubt that, like the case of the artesian well before us, the excessive amount of ammonia in the spring water had a solvent action on the zinc coating of the galvanized pipes, but that on free exposure to the air in the tank the hydrocarbonate of zinc was separated, as it appeared in a crystalline film on the surface of the water.

The amount of zinc thus carried into the water, either in suspension or in solution, appears to depend not only on the impurities in the water, but also upon the quality of the galvanized iron; both as to whether the process of coating with zinc has been properly done and as to the purity and texture of the zinc itself. If, for instance, the iron has been allowed to become spotted with rust, even if the rust is apparently well cleaned off before dipping the iron surface into the zinc bath, a more rapid corrosion, it is said, is liable to occur when the zincked article is immersed in water.

As regards the injurious effects of potable water containing zinc, the zinc oxide or carbonate carried in suspension in any large amounts would not be likely to cause trouble to health, because most people would usually refuse to drink any water so turbid without filtering it. Hence,

only the smaller amounts of suspended zinc and that which is in solution need be considered.

While it is true that in the case of the artesian well described in this paper no chemist would be likely to advise the use of this water on account of the strong suspicion of sewage contamination, yet it is suggestive of possibilities where the water is not submitted to a chemist for examination.

An interesting paper on the use of zincked or galvanized iron for the storage and conveyance of drinking water was contributed by Dr. W. E. Boardman, of Boston, to the Fifth Annual Report of the Massachusetts State Board of Health, 1874, the object of which was stated to be to determine, if possible, whether such use of this material was attended with danger of zinc poisoning, this having been asserted in the Boston *Journal of Chemistry*, in commenting upon cases of illness occurring at Spot Pond, Melrose, Mass., in 1871.

To this paper I refer as a concise statement of the opinions of numerous distinguished authors from 1795 to 1872.

"From this *résumé* of opinions and facts," says Dr. Boardman, "it may be confidently asserted that the oxide of zinc *as it occurs in drinking water* is absolutely harmless."

With regard to the carbonate of zinc, he says: "The almost universal testimony appears to point conclusively also to the innocuity of this compound."

The above conclusions are in regard to that which is in suspension only. As regards the effects of zinc in a soluble form, Dr. Boardman says: "Admitting, then, that water which has been stored in reservoirs or drawn through pipes of galvanized iron always contains zinc in solution in the form of one or more of its salts, the innocuity of those salts *in the quantities in which they occur* is attested by the experience and experiments of the various distinguished observers to whom we have already referred. While they admit the deleterious influences which may be occasioned by the soluble salts of zinc when taken internally in sufficient quantity or for a long time, they are unanimous in the recommendation of the use of zincked iron for the storing and conveyance of water." [*The italics in the above quotations are the writer's.*]

In most of the cases considered only a very small amount of zinc was found in solution; and Dr. Boardman expressly states that he does not include in his consideration the effects of waters obviously unfit for drinking on account of sewage pollution or other abnormal qualities.

Dr. Boardman, in the above-mentioned *résumé*, has followed the older writers on *Materia Medica*, but since the publication of his paper opinion seems to have become somewhat modified.

Dr. Bartholow, in his work on *Materia Medica and Therapeutics* (3d ed., 1880, p. 229, *et seq.*) says of the physiological action of the salts of zinc: "The preparations of zinc are active in proportion to their solubility and power of diffusion. The chloride sulphate and acetate are the most active, and in the order in which they are placed; the carbonate and oxide being insoluble have very feeble diffusive power and possess consequently very slight activity."

"Long-continued use of the sulphate, even in small medicinal doses, may excite ulceration of the mucous membrane. The oxide and carbonate, although insoluble and inactive, slowly produce systematic effects."

"All of the salts of zinc when long continued may produce a train of symptoms not unlike those caused by lead, viz: Emaciation, pallor, loss of strength, constipation and colic, muscular weakness and trembling, paralysis, etc."

"The oxide in large doses and used for a long period has produced wasting and fetid breath, gastro-intestinal catarrh, weakness and feeble mind."

"The zinc salts manifest much less tendency to accumulate, and are excreted much more rapidly than mercury, lead and copper."

The symptoms above described by Dr. Bartholow are, of course, to be understood as produced by very much larger quantities of zinc than ordinarily occur in water. Nevertheless, the older opinion of the almost absolute innocuity of the more insoluble forms appears to be seriously questioned, and our sense of security is correspondingly somewhat disturbed.

That zinc may also occur in a soluble form in drinking

water in quantities which may be almost called medicinal is shown by the analysis of this artesian well water. It is now well known that, as regards lead, the long continued daily use of water containing a small fraction of a grain of the metal in a gallon has had distinctly marked effect upon the system, and the chemist is advised to condemn a water carrying more than one-tenth of a grain per gallon. This is largely in consequence of the cumulative power of this metal. Zinc not possessing that power in so great a degree is proportionately less injurious.

It is true that large communities have been accustomed to drinking water slightly contaminated with zinc without any effects being apparent that could be attributed to it. Thus we may instance a large experience in this city and vicinity.

And, again, I find in *The Analyst* (vol. iv, p. 51), an abstract of a paper by E. Hylius, in which he says that the presence of minute quantities of zinc does not seem so injurious to health as is generally believed. That author analyzed a sample of spring water from Tuttendorf, in Germany, and found it to contain 0·007 grams of zinc oxide per liter, equal to 0·49 grains per imperial gallon; and he was assured that the water had been drank by the population for about a century.

This sort of evidence is, however, not conclusive by itself, for many obscure symptoms which may really be caused by small amounts of metallic poisons are liable to be attributed to a variety of other causes. The same argument may be used with regard to a public water supply from a river decidedly polluted with sewage. In the absence of an epidemic, it is often very difficult either to prove or disprove the precise deleterious effects of a sewage polluted water supply on the population of a large city.

In the same manner it has been shown that in the case of a town in Scotland, supplied with water containing a very large amount of sulphate of lime, the inhabitants did not appear to suffer any injurious consequences from drinking such a water. Yet it is a well-established opinion among sanitarians that excessive amounts of sulphate of lime in drinking water are undoubtedly productive, as a *general fact*, of diseases of the digestive organs.

Still it must be conceded that the weight of practical opinion is decidedly on the side of the innocuity of the use of galvanized iron for water pipes. Thus, as a result of a discussion at a meeting of the German Society of Gas and Water Engineers, H. Bunte collected in 1887 information to show that the use of galvanized pipes should be in no way detrimental to health. Dr. V. Ehmann, late Director of the Water Supply of Würtemburg, stated that objection to such pipes cannot be taken on sanitary grounds, and he considered them peculiarly suitable for use in the interior of buildings.

English authors on sanitation have always been opposed to the use of zinc for roofs which are to be utilized for the collection of rain water for drinking and culinary purposes.

Neither should lead or lead-coated sheet iron, called terne plate, for roofing purposes be used under such circumstances. Sheet copper is equally objectionable. All these metals or metallic combinations, if unprotected by a suitable paint, will be corroded by the free acids frequently found in the atmosphere of rural localities as well as of cities; and, also, by the ammonia always more or less present in rain water, which exerts a solvent action upon copper. The corrosion of copper by the impurities of rain water is known from practical experience with copper-roofed buildings in Europe.

In conclusion, therefore, it may be said that while under usual conditions of water-supply with pure water galvanized iron pipe may be advantageously used for its conveyance without detriment to health; yet, too much confidence should not be placed upon it. All the conditions under which the zincked pipe is to be used should be carefully considered, including a chemical analysis of the water; and, in the presence in the water of considerable amounts of certain saline substances, such as ammonia salts, chloride of sodium and nitrates, as well as very small amounts of free mineral acids, etc., galvanized iron should not be used at all. Under such circumstances, only pipes coated with a non-metallic interior surface should be used.

UTAH OZOKERITE.*

BY ALFRED N. SEAL, S.B.

[*Read at the Stated Meeting of the Chemical Section, October 21, 1890.*]

Ozokerites, in general, have been quite frequently studied, but Utah ozokerite has not been very fully investigated, and the results which have been published are of a conflicting nature. Prof. S. B. Newberry publishes † certain results as follows: "Its melting point is 61°·5.

Composition—

C,	86·15
H,	13·75
	99·90

It distils without decomposition, is not altered by strong acids or by hot alcohol, but is soluble in ether, turpentine or naphtha." He considers it a mixture of paraffines, possibly containing some admixed olefines. Wurtz, ‡ depending almost entirely upon calculations of analyses made by other chemists, pronounces the material to be an olefine. He states in proof of this that he has found the action of sulphuric acid upon it to be violent, with copious evolution of SO_2. He also states that the material does not crystallize from solvents, thus differing from the paraffines. As will be shown, the work which was here done upon this substance disproves several of the statements made above.

The material is of a dark brown color, of wax-like consistency, and has a foliated structure. Occurring with it were bundles of crystals of a white fibrous mineral, which showed by analysis that it was gypsum. The melting point is 53° to 55°; the specific gravity ·9285. The material is easily soluble in warm benzene, petroleum spirit, ether and carbon bisulphide. The dilute solution is highly fluorescent.

Alcohol precipitates a solid from the solution in benzene, and when the precipitation is carried on slowly, most of the

* Abstract of a thesis for degree at the University of Pennsylvania.

† *Eng. and Min. Jour.*, March 22, 1879.

‡ *Eng. and Min. Jour.*, July, 1889.

coloring matter comes out with the solid first precipitated, leaving a more or less clear solution. This, of course, shows that the coloring matter is less soluble in alcohol than the light colored solid which finally comes down with excess of alcohol. This is contrary to the result of Beilstein* with Caucasian ozokerite, he stating that the coloring matter is the more soluble of the two substances.

On boiling a portion of the ozokerite with absolute alcohol and then chilling the liquid, a pure white solid separated out in pearly scales, while the black residue sank beneath. The extraction was never complete, the residue, after having been subjected to this treatment in an extractor for two days, still showing traces of the white material, thus thwarting all attempts at obtaining a quantitative estimate of the amount of the white material in the ozokerite. However, by chilling the solution from the extractor, filtering, drying and weighing the white solid, it was found that at least sixty per cent. of the ozokerite consisted of this white hydrocarbon. This white material was further purified by dissolving in boiling absolute alcohol, allowing all traces of oily material to settle, and then pouring the clear solution through a warm filter. This filtrate, when chilled, gave the white solid in waxy plates.

By combustion, this hydrocarbon showed the following composition. Weight of substance taken, ·2013 grm; weight of CO_2 found, ·6297 grm., corresponding to ·1720 grm. C., weight of H_2O found, ·2603 grm., corresponding to ·0291 grm. H.

C.	85·44
H,	14·45
	99·89

A second analysis was as follows: Weight of substance taken, ·1797 grm.; weight of CO_2 found, ·5622 grm., corresponding to ·1536 grm. C.; weight of H_2O found, ·2352 grm., corresponding to ·0262 grm. H.

C,	85·47
H,	14·57
	100·04

* *Ber.* 16, 1574.

This white hydrocarbon, when melted, became of a yellowish color, of a waxy constituency, and had the specific gravity ·9708. It was easily soluble in all the solvents mentioned for the crude ozokerite, and in addition was soluble in hot absolute alcohol and in hot acetone.

To ascertain whether this substance was a saturated or an unsaturated hydrocarbon, a solution of it in CS_2 was treated on the water bath with a solution of bromine in the same solvent, the latter allowed to run in slowly. There was no decolorization of the bromine solution, no fumes were given off and apparently no action took place. This indicates that the material is a saturated hydrocarbon. Two grammes of the white material were then treated with about 15 cc. of concentrated H_2SO_4. No action took place in the cold. The flask was then heated for two hours at 75° and then for a few minutes at 100°. Only a very faint odor of SO_2 was perceptible. A large excess of water was then added and the whole warmed, well shaken and then chilled. The cake of wax which rose to the top was darker in color, but not blackened. The filtrate was neutralized with $PbCO_3$ and filtered. The solution was then evaporatedto dryness, when a very small amount of a yellowish salt, insoluble in water, remained. This marked resistance to the action of a strong acid indicates that the material is a paraffine.

The white hydrocarbon when highly heated broke up into an oily mass and a solid, together with carbon, and had an empyreumatic odor.

To determine, if possible, the molecular weight of the hydrocarbon, the Raoult method was employed. The apparatus recommended by Beckman was used, with a thermometer graduated to tenths. The solvent used was benzene which had been purified by crystallization, the freezing point of which was 5°·5. Tetra- and di-bromdiacetyl were used in standardizing the solvent. The results were as follows:

					MOLECULAR WEIGHT.	
	C.	*L.*	*P.*	*A.*	*From Formula with 49 as constant.*	*Theoretical.*
$C_4H_2O_2Br_4$.	·4	13·9240	·4233	·1315	371	370
$C_4H_4O_2Br_2$.	·47	17·0325	·3240	·2470	198	212

Hence, in working with the paraffine, the factor 49 was employed as given by Raoult for neutral organic substances with benzene as the solvent.

In trying to employ the method with the paraffine, great trouble was experienced, the solubility of the substance in benzene at 5° being so slight that it was necessary to have a solution so dilute, that the depression of the freezing point was only ·1°. On using a less dilute solution, the paraffine separated out in the form of a jelly, when the solution was cooled. The results were as follows:

C.	*L.*	*P.*	*A.*	*M.*	*Average for M.*
·1	14·8625	·0853	·1742	280	256
·1	26.2820	·1253	·2097	233	—

Four grammes of the crude ozokerite were treated with concentrated H_2SO_4 in the same way that the white hydrocarbon had been. A decided odor of SO_2 was noticeable, but no such fumes or violent action as noticed by Wurtz was observed. A white granular residue, weighing about ·2 grs., remained on evaporating the neutralized filtrate. This indicates that there was contained in the crude ozokerite a small proportion of olefines, which were attacked by the sulphuric acid. The small amount of a salt obtained from the white hydrocarbon was probably due to the fact that a complete separation had not been effected by the means employed.

A yellow, oily material, with a melting of about 40°, was obtained as a residue in the purification, since its solubility in hot alcohol was less that of the white hydrocarbon. This could not be obtained pure in sufficient quantities to warrant an investigation, but its properties would seem to indicate that it was an olefine.

The results given evidently do not agree with those given by Wurtz. The main mass of the ozokerite is not readily attacked by reagents, and does crystallize very readily from solvents. This is sufficient proof to show that it is a paraffine. The melting point and percentage composition of the hydrocarbon would designate it as one of the higher paraffines, and would place it about $C_{25}H_{52}$. The molecular

weight, as given by the Raoult method, would give about $C_{18}H_{38}$. The true formula, if it is a simple body, probably lies between these two.

No attempt has been made to deduct the chemical nature of the material from the analyses, since, with so great a molecular weight, a difference of two hydrogen atoms, necessary to distinguish a paraffine from an olefine could not be determined.

The specimen of ozokerite upon which this investigation was made was furnished me by Dr. Sadtler, under whose direction the work was carried out, and to whom, as well as to Dr. Keller, my thanks are due.

UNIVERSITY OF PENNSYLVANIA, June, 1890.

NOTES AND COMMENTS.

CHEMISTRY.

MANUFACTURE OF TANNINS FREE FROM COLORING MATTER. A. Villon, *Bull. Soc. Chem.*, 1890, 784. Through *Journal of Soc. Chem. Ind.*—To prepare tannin free from coloring matters from chestnut wood, quebracho, dividivi, sumac and other astringents, an extract is first obtained in the usual way, using six vats and a current of carbonic acid at a temperature of 80° to 90°. This is cooled in ordinary settling vats, the liquor drawn off and 0·5 per cent. of zinc sulphate added. The temperature is then maintained for half an hour at + 2° by means of a refrigerating vat similar to those used in breweries; the precipitated impurities are separated in a filter-press. The filtrate is transferred to a closed vat, provided with a mechanical agitator; a solution of zinc sulphate is then added in the proportion of 2·5 kilos of the salt per kilo of tannin present, and a current of ammonia gas (obtained by decomposing 2·5 kilos of ammonium sulphate per kilo of tannin) is passed in and the whole heated to boiling. The excess of gas is collected in another vat. Tannate of zinc is thus precipitated, and ammonium sulphate left in solution; the former is separated in a filter-press, washed successively with warm and cold ammoniacal water and with cold water, then suspended in five times its volume of water and decomposed with dilute sulphuric acid. A solution of barium sulphide is then added till no further precipitate is formed, and the precipitate, which consists of zinc sulphide and barium sulphate, removed by filtration. An almost colorless liquid is thus obtained, containing twenty to thirty per cent. of tannin (10° to 15° B.) and quite free from extractive matters.

The ammonia is recovered from the filtrate of the zinc tannate. The mixed precipitate of zinc sulphide and barium sulphate is treated with dilute sulphuric acid, zinc sulphate passing into solution. The barium sulphate is then reconverted into the sulphide by calcination with coal. H. T.

BOOK NOTICES.

MINERAL RESOURCES OF ONTARIO. Report of the Royal Commission on the Mineral Resources of Ontario and Measures for their Development. Printed by order of the Legislative Assembly. Toronto: Warwick & Sons. 1890.

The act appointing John Charlton, Robert Bell, William Coe, Wm. Hamilton Merritt and Archibald Blue Commissioners for reporting, as above, was passed by the Provincial Assembly of Ontario, in 1888, and the report was issued by the Commissioner of Agriculture, in May, 1890.

The time has been well spent by the distinguished Commissioners and a report has been produced of the greatest value to geologists and political economists in Canada and everywhere else.

(1) The geology of the Province and the organization of a Bureau of Mines for the Province was undertaken by Dr. Robert Bell.

(2) The description and maps of working mines and undeveloped mineral resources and the founding of a geological and mineralogical museum was assigned to Mr. Merritt.

(3) The trade question of mineral products, such as exports and imports, was treated by Mr. John Charlton, the Chairman.

(4) Information and suggestions as to mining laws and regulations fell to the lot of the Secretary, Mr. Archibald Blue, as well as

(5) The best means of promoting the metallurgical industry; the collection and publication of mining statistics, and technical instruction in mining and metallurgy.

Each one of these subjects is treated in a masterly and exhaustive manner, and the list of mining schools and glossary of mining terms, at the end of the book, are very valuable additions to our general statistical information.

F.

HANDY LISTS OF TECHNICAL LITERATURE. Compiled by H. E. Haferkorn and Paul Heise. Part 3. Engineering and Mechanics. Milwaukee: Heise & Haferkorn. 1890.

This volume contains a description of books belonging to the classes named which have been published between the years 1880 and 1888, a select list of works and editions issued previous to 1880 and during 1889 and 1890.

It is arranged according to subjects and authors in one alphabet. The author, title, place of publication, date, size and price of each work is given, then an abbreviation consisting of one, two or three letters, for the publishers. A key is furnished in which these abbreviations are alphabetically arranged

and interpreted, giving name and address of the publisher or his representative.

The volume is admirably arranged and will, no doubt, prove a valuable acquisition to the engineer and scientific student.

We hope the compilers will continue their work and soon issue "Handy Lists" of the other branches of science. R.

PRACTICAL DYNAMO-BUILDING FOR AMATEURS. HOW TO WIND FOR ANY OUTPUT. By Frederick Walk r. Illustrated. D. Van Nostrand Company: New York. 1890. 50 cents. 104 pp.

This little book is one of the Van Nostrand Science Series and is a convenient size for the pocket. It is the first American, from the second revised, English edition. The object of the book is to instruct an amateur how to build a dynamo of a certain fixed type and size. It consists of working drawings of the parts with all their dimensions, accompanied by instructions how to proceed to construct the frame and how to wind it as either a series or a shunt machine. The only tools required are those found in any good amateur workshop, including an eight-inch screw-cutting lathe, with a gap bed for a radius of eighteen inches. It assumes but very little more than a familiarity of the terms, on the part of the reader, and can, therefore, be understood by any beginner, not necessarily an electrician.

For the purpose for which it is intended, it is a good book, and it will doubtless find many readers. The instructions are practical, and in most cases full and clear, being in terms which may be understood by any amateur. The author has selected one form and size of the Gramme type for which he gives all dimensions. The dynamo selected is for about 110 volts and nine to ten ampères, consequently for about one kilowaht, or one and one-third horse-power of current. It includes a somewhat crude and elementary method of calculating some of the dimensions of the windings, which is, perhaps, all that could be expected in a small book of this kind. It concludes with some general and necessarily condensed information regarding leads, storage batteries, arc lights, electro-plating and motive-power.

The purpose of the book is, therefore, to instruct the reader how to construct this particular dynamo. Its title, which covers a much broader field, is, therefore, misleading. In the opinion of the reviewer, it would have been much better to have limited the title to the true scope of the book. The instruction, as far as determining the wire is concerned, would hardly be of much use for any other machine. It is to be regretted that the type chosen is of an old form, and the proportions are by no means the best; the machine will, therefore, not be as efficient in output as it might have been made. The fact that the induction assumed is at the rate of three yards per volt, shows that the proportions cannot be the best. Besides some inconsistencies, there are a few points which might be criticised unfavorably, but they are, perhaps, of no great importance to the amateur. One of these, which *is* of importance to the builder, is that the armature links must be stamped out (there is no alternative), and if the particular dies are not at the disposal of the

builder, he must go to the expense of having them made, which will, in most cases, be too great an expense. It is highly improbable that these dies be found anywhere except, perhaps, in London, where they were doubtless made for this special purpose. He states that these links may be bought for $1 per gross, but, unfortunately the reader is left to find out where to buy them.

In some cases, the language is not clear and will doubtless give the builder some trouble. For instance, in his own calculations, the same frame when series-wound will have double the ampère turns in the field that are required when shunt-wound. There is evidently something wrong somewhere and the reader, if of an inquiring mind, as is generally the case, will be greatly puzzled. Such over-saturation surely cannot have been intended.

C. H.

RAILROAD ENGINEERS' FIELD-BOOK AND EXPLORERS' GUIDE. Especially adapted to the use of Railroad Engineers on Location and Construction, and to the needs of the explorer in making Exploratory Surveys. By H. C. Godwin. New York: John Wiley & Sons. 1890.

This well-got-up little book compares favorably with others of its class. It is devoted almost exclusively to the geometrical portion of an engineer's work. The first half covers the usual ground, with rather more than the usual attention to the subject of train resistance, in which respect the author, like the rest of us, is indebted largely to Mr. Wellington and his "Railway Location."

The second half of the book is devoted mainly to "Exploratory Surveying," and will, we think, be found by most railroad engineers to be rather more heavily charged with astronomy than is required for their purposes. The remarks under this head are followed by a short "miscellaneous," Part IV, in which, besides a few pages of trigonometry, are grouped a number of somewhat incoherent memoranda, harmless, no doubt, if not taken too implicitly, but scarcely of sufficient thoroughness to be of great value.

The book concludes with about a hundred pages of tables. Most of these are evidently taken bodily from Searles, even to the arrangement of the pages, and, so far as we can see, without acknowledgment. T.

A NATURAL METHOD OF PHYSICAL TRAINING, MAKING MUSCLE AND REDUCING FLESH WITHOUT DIETING OR APPARATUS. By Edwin Checkley. Fifth edition. Fully illustrated from photographs taken especially for this treatise. Brooklyn, N. Y.: Wm. C. Bryant & Co. 1890.

The writer of this small octavo of 152 pages comes before the public like Francis Galton, without any title from the school of medicine, and, like Francis Galton, he displays a familiarity with the structure and functions of the body which adds very much to the charm and the convincing force of his book. He has many points which favor him before the public, such as an earnest and withal a very clear and pleasant style; a subject which interests everybody and will draw everybody's attention so soon as the writer inspires confidence in his knowledge of the subject, which Mr. Checkley very shortly does. Then the means which he employs are simple and natural, and being

always at hand, leave the would-be physical reformer no excuse for missing his exercise. The theory put forth by Mr. Checkley is not new, but it is very strongly stated. It is, in short, that with the attention called to such points as the correct carriage of the body, the proper manner of breathing, and the repetition, morning and evening for twenty minutes or so, of such motions as bring into play the muscles on which the daily routine makes no demand, not only the general health and power of sleep are improved, but also the physical strength is greatly increased, the tendency to corpulence checked and its unpleasant consequences avoided.

Even were there no examples of the practical success of this system, its simplicity and reasonableness would take one captive, but the writer has seen a practical proof of its beneficent working on a short and very fleshy man, whose pursuits were so little favorable to the maintenance of the well-proportioned frame, and whose occupations were so exacting and numerous that he had fallen into that bourne of rotundity and flaccid muscles from which few can return. For years he had seriously projected correcting this evil by gymnasium exercise, but had never "found the time," and was rapidly tending towards the outline of a human sphere. Finally, this little book fell into his hands, and he made a determined effort to follow its precepts.

Without subjecting himself to any unusual deprivation by diet, he began rapidly to reduce his excessive corpulence, until in three weeks his trunk had changed from the appearance of a pear to that of a barrel, his waist measure had diminished from forty-one inches to thirty-six and one-half, while his chest measure had increased. A neck began to be visible; short breath became a nightmare of the past, and almost without effort he assumed the proportions of an athlete.

It may well be that all will not have the strength of will to carry out this regimen so faithfully, and will not so soon reap their reward; but that it will prove beneficial to all is certain. The advice it contains as to the physical training of women and children is timely and admirable.

The writer is not acquainted with any treatise on the art of preserving health and comfort, or of regaining them when lost, by natural and inexpensive means, which is so sensible, so practical and so clear as this little book, which is heartily recommended to the public. F.

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[*Proceedings of the Stated Meeting, held Wednesday, October 15, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, October 15, 1890.

JOS. M. WILSON, President, in the Chair.

Present, 204 members and thirty-six visitors.

Additions to membership since last report, seven.

The Secretary reported the resignations of Messrs. Francis LeClere and J. H. Eastwick as members of the Committee on Science and the Arts. An election was ordered to fill the vacancies, and resulted in the choice of—

Mr. Reuben Haines to fill the unexpired term of Mr. Eastwick; and of Mr. Arthur Church, for the unexpired term of Mr. LeClere.

Mr. Alfred Shedlock, of New York, exhibited an improved lamp for

engineering uses, intended for the illumination of large areas, and described its construction and operation. (Referred for publication.)

Mr. S. Lloyd Wiegand presented a description, with illustrations, of the Hammond typewriter, embodying the results of the examination of this instrument by the Committee on Science and the Arts.

At the conclusion of his remarks, Mr. Edw. J. Manning, an expert operator, gave a remarkable demonstration of the celerity with which the instrument could be worked. Taking a given sentence of ten words, he succeeded, in four successive trials (each of one minute's duration, accurately timed), in writing, respectively, 150, 160, 170, and 170 words.

Mr. W. N. Jennings exhibited an interesting suite of photographs of views taken by himself in a recent visit to Chinatown, in San Francisco, Cal.

The Secretary's report was omitted, on account of the lateness of the hour.

The Secretary made mention of the fact that Dr. Persifor Frazer, Professor of Chemistry in the Institute, had received the decoration of the Palms of the Academy as Officer of Public Instruction, from the Government of France.

Mr. G. M. Eldridge offered the following preamble and resolutions, which, on being put to vote, were adopted without dissent, viz:

WHEREAS, An act to increase the efficiency and reduce the expenses of the Signal Corps of the Army, and to transfer the Weather Service to the Department of Agriculture has become a law; and,

WHEREAS, The high standard and efficiency of the Pennsylvania State Weather Service, under the direction of the Meteorological Committee of Franklin Institute, is largely due to the aid received from the Signal Service of the Army; therefore,

Be it resolved, That the thanks of the Franklin Institute are due and are hereby tendered—

To General A. W. Greely for the liberal policy he has pursued towards the Pennsylvania State Weather Service;

To Capt. H. H. C. Dunwoody for his valuable aid in the organization of the State Service and his active interest in promoting its growth and usefulness;

To Sergt. T. F. Townsend for his energy and zeal in carrying out the instructions and wishes of the Meteorological Committee;

And to the Corps of Observers and Displaymen who have freely contributed their labors in bringing the Service to its present high standard. And be it further,

Resolved, That in the reorganization of the Weather Bureau it is the hope of the Franklin Institute that the State Service may continue to receive the same substantial aid as in the past, in order that it may prove a still more important auxiliary to the work of the National Weather Bureau.

Adjourned. WM. H. WAHL, *Secretary*.

PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR SEPTEMBER, 1890.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, September 30, 1890.

TEMPERATURE.

The mean temperature of 57 stations for September, 1890, was 62°·0, which is about 1°·0 above the normal, and 0°·1 above the corresponding month of 1889.

The mean of the daily maximum and minimum temperatures 72°·4 and 52°·1 give an average daily range of 20°·3, and a monthly mean of 62°·2.

Highest monthly mean, 67°·2 at Philadelphia.

Lowest monthly mean, 56°·4 at Wellsboro, Dyberry, and Waynesburg.

Highest temperature recorded during the month, 91° on the 5th at Coatesville and Carlisle, and on the 7th at McConnellsburg.

Lowest temperature, 25° on the 25th at Dyberry.

Greatest local monthly range, 26°·4 at Phillipsburg.

Least local monthly range, 14°·0 at Erie.

Greatest daily range, 49°·0 at Huntingdon on the 20th.

Least daily range, 1°·0 at Drifton on the 11th, Selins Grove 14th, and Columbus 27th.

From January 1, 1890, to September 30, 1890, the excess in temperature at Philadelphia was 681°, at Erie 183° and at Pittsburgh 652°.

The warmest period of the month was from the 2d to the 8th, inclusive. The coldest was from the 25th to the end of the month.

Frosts were quite general on the 25th, 28th, 29th, and 30th.

BAROMETER.

The mean pressure for the month, 30·135, is about ·05 above the normal. At the U. S. Signal Service Stations, the highest observed was 30·39 at Pittsburgh and Erie on the 28th, and the lowest 29·80 at Erie on the 13th.

PRECIPITATION.

The average rainfall 4·57 inches for the month, is an excess of one inch.

The largest monthly totals in inches were Ligonier, 8·54; Indiana, 8·10; Somerset, 7·84; Emporium, 7·91; New Castle, 7·48; and Columbus, 7·10.

The least were South Eaton, 2·05; State College, 2·29; Philadelphia, 2·31; Petersburg, 2·35; Wilkes-Barre, 2·42; Swarthmore, 2·62; McConnellsburg, 2·62 and Harrisburg, 2·89.

General rains occurred from the 11th to the 15th inclusive, and on the 26th and 27th. Excessive rains were reported from Wellsboro on the 9th and 10th; Myerstown and Meadville on the 11th and 12th, and at York on the 12th and 13th.

NOTE.—An actual fall of 2·50 inches in any period of 24 hours, or one inch in one hour, is excessive precipitation.

WIND AND WEATHER.

The prevailing wind was from the northwest. The weather was generally favorable for the harvesting and curing of late crops, and for fall seeding.

Average number: Rainy days, 11; clear days, 10; fair days, 9; cloudy days, 11.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Charlesville, 5th; Blue Knob, 5th, 7th, 8th, 9th, 10th, 11th, 12th, 16th; Hollidaysburg, 8th, 16th, 24th; Tipton, 4th, 8th, 16th; Le Roy, 16th; Quakertown, 5th, 12th, 13th, 16th; Johnstown, 8th, 9th, 16th; Emporium, 5th, 12th, 16th; Mauch Chunk, 7th; State College, 16th; West Chester, 5th, 12th; Coatesville, 5th, 12th; Kennett Square, 5th, 6th, 12th, 16th; Phœnixville, 16th, 17th; Westtown, 5th; Rimersburg, 11th, 15th, 16th; Catawissa, 5th, 16th; Meadville, 3d, 8th, 11th, 15th; Carlisle, 16th; Harrisburg, 16th; Swarthmore, 6th, 13th, 15th, 17th; Uniontown, 5th, 6th, 7th, 8th; Petersburg, 16th; Indiana, 7th, 9th, 10th, 16th; Myerstown, 12th, 13th; Coopersburg, 12th, 13th; Philadelphia, 6th, 15th; Girardville, 12th, 16th; Selins Grove, 12th, 13th; Somerset, 7th; Wellsboro, 9th, 16th; Lewisburg, 5th, 12th, 16th; Columbus, 16th; Dyberry, 7th, 12th, 13th; Ligonier, 5th, 9th; South Eaton, 5th, 16th; York, 5th, 12th.

Hail.—Johnstown, 16th.

Snow.—Blue Knob, 20th.

Frost.—Pittsburgh, 28th, 29th; Charlesville, 25th, 29th; Altoona, 24th, 25th, 27th, 28th; Blue Knob, 1st, 24th, 25th, 28th, 29th, 30th; Hollidaysburg, 25th, 28th, 29th; Tipton, 1st, 2d, 25th, 28th, 29th; Wysox, 28th; Le Roy, 25th, 29th, 30th; Forks of Neshaminy, 25th; Quakertown, 25th, 29th, 30th; Emporium, 28th; State College, 25th, 28th, 29th, 30th; Phillipsburg, 1st, 21st, 22d, 23d, 24th, 25th, 28th, 29th, 30th; Coatesville, 25th, 29th, 30th; Phœnixville, 25th, 29th, 30th; Westtown, 25th; Rimersburg, 1st, 24th, 28th, 29th; Grampian Hills, 1st, 25th, 28th, 29th, 30th; Catawissa, 25th, 28th, 29th, 30th; Meadville, 1st, 2d, 25th, 29th, 30th; Waynesburg, 2d; Huntingdon, 28th, 29th; Petersburg, 2d, 25th, 28th; Indiana, 28th, 29th, 30th; Lancaster, 25th, 30th; New Castle, 28th, 29th; Myerstown, 19th, 25th, 29th, 30th; Coopersburg, 25th; Wilkes-Barre, 29th, 30th; Nisbet, 25th, 28th; Greenville, 24th, 25th, 29th; Bethlehem, 25th, 29th; Philadelphia, 25th, 29th; Girardville, 21st, 23d, 24th, 25th, 26th, 28th, 29th, 30th; Selins Grove, 25th, 28th, 29th; Somerset, 1st, 24th, 28th, 30th; Wells-

ICE FOR SEPTEMBER, 1890.

County.	Precipitation. Number of Days Rainfall.	Number of Days. Clear.	Fair.	Cloudy.	Wind. Prevailing Direction. 7 A. M.	2 P. M.	9 P. M.	Observers.
Adams,[1]	...	...	...	...	...	...	...	Prof. E. S. Breidenbaugh.
Allegheny,[1]	14	7	14	9	S	S	S	Oscar D. Stewart, Sgt. Sig. Corps.
Bedford,	11	10	11	9	N	SW	N	Miss E. A. G. Apple.
Blair,[2]	14	...	...	...	...	...	...	Dr. Charles B. Dudley.
Blair,	13	8	10	12	SW	NW	NW	A. H. Boyle.
Blair,	13	10	10	10	W	W	SW	Prof. J. A. Stewart.
Blair,	10	8	11	11	W	W	W	Miss Cora J. Wilson.
Bradford,	10	12	3	15	SE	W	SE	Charles Beecher.
Bradford,	11	11	7	12	SW	SW	SW	Geo. W. T. Warburton.
Bucks,	12	14	8	8	N	N	N	J. C. Hilsman.
Bucks,	10	11	10	9	SW	SW	SW	J. L. Heacock.
Cambria,[1]	14	9	10	11	S	S	S	E. C. Lorentz.
Cameron,	12	12	7	11	NW	NW	NW	T. B. Lloyd.
Carbon,[1]	11	11	10	9	NW	NW	NW	John J. Boyd.
Centre,	13	8	12	10	N	SW	SW	Prof. Wm. Frear.
Centre,	12	10	8	12	SW	SW	SW	Geo. H. Dunkle.
Chester,	12	13	8	9	NW	S	S	Jesse C. Green, D.D.S.
Chester,	9	12	10	8	W	W	S	W. T. Gordon.
Chester,[1]	11	11	8	11	N	N	N	Benj. P. Kirk.
Chester,	9	7	9	14	NW	...	SE	Knowles Croskey.
Chester,	9	11	6	12	W	W	E	Prof. Wm. F. Wickersham.
Clarion,	14	9	13	8	N	W	W	Rev. W. W. Deatrick, A.M.
Clarion,	...	...	...	...	...	...	...	C. M. Thomas, B.S.
Clearfield,	13	4	16	10	E	SW	E	Nathan Moore.
Clinton,	15	11	10	9	W	W	W	Prof. John A. Robb.
Columbia,	9	...	...	...	...	...	...	Robert M. Graham.
Crawford,	10	11	9	10	S	S	S	J. & B. H. Metcalf.
Cumberland,	11	10	12	7	S	S	W	J. E. Pague.
Dauphin,[1]	11	10	9	10	E	E	E	Frank Ridgway, Sgt. Sig. Corps.
Delaware,	9	1	11	18	S	SW	NW	Prof. Susan J. Cunningham.
Erie,[1]	13	8	11	11	S	S	S	Peter Wood, Sgt. Sig. Corps.
Fayette,	10	16	11	3	SW	SW	SW	Wm. Hunt.
Franklin,[1]	...	...	...	...	...	...	...	Miss Mary A. Ricker.
Fulton,	7	9	13	8	...	...	...	Thomas F. Sloan.
Greene,	9	9	10	11	...	...	...	Capt. W. C. Kimber.
Huntingdon,[1]	5	19	4	7	W	W	W	Prof. W. J. Swigart.
Huntingdon,	9	12	11	7	W	W	W	J. E. Rooney.
Indiana,	13	8	12	10	N	NW	NW	Prof. S C. Schmucker.
Lancaster,	4	4	9	9	NW	NW	NW	C. N. Heller.
Lawrence,	12	11	10	9	S	S	E	Wm. T. Butz.
Lebanon,	8	9	3	18	W	W	W	Wm. H. Kline.
Lebanon,	...	...	...	...	...	...	...	Geo. W. Bowman, A.M., Ph.D.
Lehigh,	9	10	7	13	NE	SE	NE	M. H. Boye.
Lehigh,[1]	...	4	13	13	...	...	...	John C. Wuchter.
Luzerne,	7	...	...	...	...	...	...	H. D. Miller, M.D.
Luzerne,[1]	8.	13	2	15	E	E	E	A. W. Betterly.
Lycoming,[1]	7	...	...	...	...	...	...	John S. Gibson, P. M.
Mercer,[1]	13	7	10	13	S	S	S	Prof. S. H. Miller.
Mifflin,	...	...	...	...	...	...	...	Culbertson & Lantz.
Montgomery	8	14	9	7	NW	SW	SW	Charles Moore, D.D.S.
Northampton	7	15	5	10	W	W	W	Lerch & Rice.
Philadelphia	11	9	7	14	NE	NE	NE	Luther M. Dey, Sgt. Sig. Corps.
Schuylkill,	9	16	3	11	NW	W	NW	E. C. Wagner.
Snyder,	7	7	14	9	SE	SE	SE	J. M. Boyer,
Somerset,	10	9	8	13	NW	NW	NW	W. M. Schrock.
Sullivan,	10	12	5	13	SW	SW	SW	E. S. Chase.
Tioga,	11	4	11	15	S	S	S	H. D. Deming.
Union,[1]	10	8	15	7	SW	SW	SW	F. O. Whitman.
Warren,	12	9	10	11	SW	SW	SW	Wm. Loveland.
Washington,	...	...	...	...	...	...	...	A. L. Runion, M.D.
Wayne,	10	12	4	14	W	NW	W	Theodore Day.
Wayne,	13	...	...	...	...	...	...	John Torrey.
Westmoreland	13	15	8	7	...	...	...	J. T. Ambrose.
Wyoming,[1]	9	12	5	13	NW	NW	NW	Benj. M. Hall.
York,[1]	9	20	3	7	NW	NW	NW	Mrs. L. H. Grenewald.

[1] Observa

T. F. TOWNSEND, *Sergeant Signal Corps, Assistant.*

	Germantown.	Point Pleasant.	Bethlehem.	Canonsburg.	Carlisle.	McConnellsburg.	Waynesburg.	Lewisburg.	Mauch Chunk.	Nisbet.	Charlesville.	Lynnport.	Gettysburg.	Lewistown.	Tipton.	Coudersport.	Coopersburg.	Westtown.	Meadville.	Ligonier.	Scranton.	Phœnixville.	Hamburg.	Browers Lock.	Reading.
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1	. .	. .	·11	. .	·10	·15	1·80	·07	·13	. .	·31	. .	. .	. .	·09	. .	. .	. .	. .	·76	. .	. .	. .	. .	·02
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.	. .	. .	. .	. .	. .	. .	·40	·04	. .	. .	·22	. .	. .	. .	·43	. .	. .	. .	. .	·16	. .		. .	. .	. .
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.	·20	. .	. .	. .	. .	. .	·20	. .	. .	·30	.	. .	. .	. .	. .	. .	. .	. .	1·23	1·05	. .	. .	. .	. .	. .
4	·60	. .	·52	. .	·12	·46	. .	·02	·17	·30	1·20	. .	. .	. .	·18	. .	·40	·20	1·38	·10	. .	·11	. .	·16	·01
5	. .	·85	1·36	. .	·31	·75	. .	·14	1·72	. .	·66	. .	. .	. .	·05	. .	1·12	·37	2·35	·18	. .	·76	1·06	·09	1·66
0	·05	·24	. .	. .	2·23	. .	·40	1·75	·43	1·30	. .	. .	. .	. .	. .	. .	1·02	. .	·07	·17	. .	·38	·68	·36	1·17
2	·73	·15	·55	. .	·20	·09	·30	. .	·32	. .	·12	. .	. .	. .	. .	. .	·37	·01	. .	. .	. .	·01	·58	. .	·01
1	·40	·80	·56	. .	·10	. .	. .	·16	·75	. .	. .	. .	. .	. .	. .	. .	·70	·90	. .	. .	. .	·90	·35	·74	·32
6	·22	. .	. .	.	·06	·25	·60	1·02	·29	1·00	·29	. .	. .	. .	·77	. .	·19	1·17	·22	1·05	. .	·29	20	·30	·01
7	. .	. .	·18	. .	·28	. .	. .	·09	. .	. .	. .	. .	. .	. .	. .	. .	·02	. .	·14	. .	. .	·06	·04	·25	·01
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9	·57	·40	·23	. .		·83	·80	·30	·32	·30	·11	. .	. .	. .	·95	. .	·40	·74	·21	1·50	. .	·52	. .	·56	·75
3	·01	. .	. .	. .	·72	·09	1·20	·11	. .	·20	. .	. .	. .	. .	·15	. .	·01	·20	·15	·28	. .	·06	. .	·08	·01
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4	2·83	2·44	3·51	. .	4·12	2·62	5·90	3·70	4·64	3·90	4·05	5·20	. .	. .	3·67	. .	1·18	3·60	5·82	8·54	. .	3·09	3·94	2·54	3·98

T. F. T.

'boro, 1st, 2d, 21st, 25th, 28th, 29th, 30th; Lewisburg, 30th; Columbus, 1st, 2d, 25th, 29th, 30th; Dyberry, 25th, 28th, 29th, 30th; Honesdale, 25th, 29th, 30th; Ligonier, 28th, 29th; South Eaton, 25th, 28th, 29th; York, 25th, 29th, 30th; Eagles Mere, 25th, 28th, 30th.

Coronæ.—Charlesville, 23d; Dyberry, 21st, 25th; Eagles Mere, 25th.

Solar Halos.—Le Roy, 14th, 22d, 25th; Meadville, 5th, 14th, 18th; Eagles Mere, 14th, 24th, 25th.

Lunar Halos.—Charlesville, 18th; Hollidaysburg, 25th; Phœnixville, 23d, 28th; Meadville, 27th; Carlisle, 28th; Lancaster, 22d, 23d; Somerset, 29th, 30th; York, 25th.

Meteors.—Charlesville, 23d.

Earthquake.—Phœnixville, 4th.

WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for September, 1890:

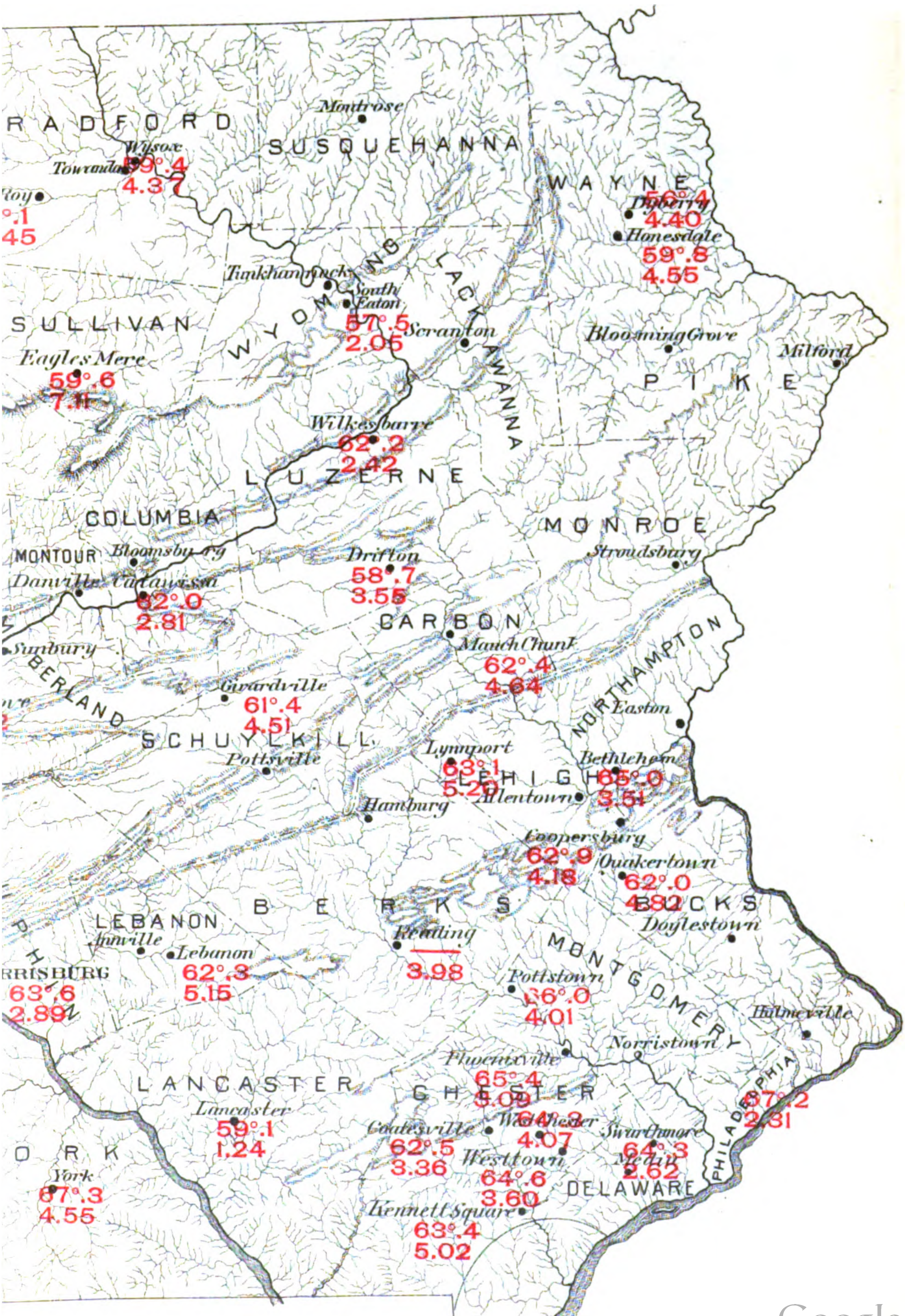
Weather, 88 per cent.
Temperature, 90 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
C. W. Burkhart,	Shoemakersville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
Capt. A. Goldsmith,	Quakertown.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
New Era,	Lancaster.
D. G. Hurley,	Altoona.

Displayman.	*Station.*
J. E. Forsythe,	Butler.
Steward M. Dreher,	Stroudsburg.
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. M. Wildman,	Langhorne.
G. W. Klee,	Chambersburg.
A. Simon's Sons,	Lock Haven.
Raftsman's Journal,	Clearfield.
R. C. Schmidt & Co.,	Belle Vernon.
Chas. B. Lutz,	Bloomsburg.
E. C. Lorentz,	Johnstown.
W. M. James,	Ashland.
Miller & Allison,	Punxsutawney.
Dr. A. L. Runion,	Canonsburg.
E. J. Sellers,	Kutztown.
C. A. Hinsdell,	Scranton.
H. M. Kaisinger,	Hartsville.
Foulk & Co.,	Milford.
William Lawton,	Wilmington, Del.
Wister Heberton & Co.,	Germantown.
Charles M. Mullen,	Bedford.
E. W. Merrill,	North East.
A. Simon's Sons,	Lock Haven.
Frank Ridgway,	Harrisburg.
G. W. Yost,	Collegeville.
A. C. Tryon,	Spartansburg.
A. H. Gerbench,	Annville.
Knowles Croskey,	Phoenixville.
Powell Bros.,	Shadeland.
Lincoln E. Rowley,	Athens.

TEMBER, 1890.


RADFORD
Wysox
Towanda
59°.4
4.37
Montrose
SUSQUEHANNA
WAYNE
Dyberry
56°.4
4.40
Honesdale
59°.8
4.55
Tunkhannock
South Eaton
57°.5
2.05
WYOMING
LACKAWANNA
Scranton
SULLIVAN
Eagles Mere
59°.6
7.11
Blooming Grove
Milford
PIKE
Wilkesbarre
62°.2
2.42
LUZERNE
COLUMBIA
MONROE
MONTOUR
Bloomsburg
Stroudsburg
Drifton
58°.7
3.55
Danville
Catawissa
62°.0
2.81
CARBON
Mauch Chunk
62°.4
4.64
Sunbury
NORTHAMPTON
Girardville
61°.4
4.51
Easton
SCHUYLKILL
Pottsville
Lynnport
63°.1
5.20
LEHIGH
Bethlehem
65°.0
3.51
Allentown
Hamburg
Coopersburg
62°.9
4.18
Quakertown
62°.0
4.82
BUCKS
LEBANON
BERKS
Doylestown
Annville
Lebanon
62°.3
5.15
Reading
3.98
MONTGOMERY
Pottstown
66°.0
4.01
63°.6
2.89
Holmesville
Norristown
Phoenixville
65°.4
5.09
LANCASTER
CHESTER
Lancaster
59°.1
1.24
West Chester
64°.8
4.07
PHILADELPHIA
67°.2
2.81
Coatesville
62°.5
3.36
Swarthmore
Media
64°.3
2.62
Westtown
64°.6
3.60
DELAWARE
York
67°.3
4.55
Kennett Square
63°.4
5.02

INDEX TO THE REPORTS

— OF THE —

Committee on Science and the Arts

— OF THE —

Franklin Institute of the State of Pennsylvania,

1884-1890.

COMPILED

UNDER THE DIRECTION OF THE COMMITTEE

— BY —

PERCY A. BIVINS

AND PUBLISHED BY THE AUTHORITY OF THE INSTITUTE.

PHILADELPHIA:

1890.

PRESS OF
EDWARD STERN & CO.
PHILADELPHIA.

PREFACE.

The Committee on Science and the Arts of the Franklin Institute was organized in 1834, for the purposes expressed in the following quotation from the By-Laws of the Institute:

"To perform such duties as may devolve upon them, and to sustain by their labors the scientific character of the Institute."

Originally this committee consisted of such members of the Institute as should voluntarily enroll themselves as pledged to perform such work, and their reports were submitted to the Institute for ratification.

To this committee were referred the examination of new inventions and discoveries, and recommendations for rewards for meritorious inventions.

With the rapid progress of the arts the number of applications for awards greatly increased, and with it the danger of erroneous recommendations from a voluntary committee. In 1887, the committee was reorganized so as to be elective, consisting of forty-five members, fifteen being chosen annually for a term of three years, and their action was accepted as the decision of the Institute.

Up to the year 1888, about 1,500 examinations and reports had been made, which were simply filed away in numerical order. A knowledge of their contents (excepting those that had been published) rested only in the recollections of the members. Comparatively few of the earlier members now survive.

The value of these reports as indicating earlier states of art was recognized by the Committee, and in order to render them accessible for reference, the following preamble and resolutions were adopted by the Committee at their meeting of October 2, 1889:

"WHEREAS, There have been a large number of reports prepared by the Committee on Science and the Arts which are not within the knowledge or recollection of many of the present membership of the Committee and are not useful or convenient for reference, for the reason that there is no index or catalogue setting forth their subject-matter, although many of these reports contain valuable and exact information as to the state of many arts in earlier periods;

"AND, WHEREAS, Provision has been made without cost to the

Institute for the expense of clerical services incurred in the preparation of suitable subject-matter indices for said reports, from the first reports issued to this date, such intended indices being

"(1) Of the names of applicants for examination.*

"(2) Of the names of the inventors.

"(3) Of the title of the invention; and

"(4) Of the subject-matter as classified to conform to the system of classification now employed in the U. S. Patent Office;

"*Therefore Resolved*, that a committee be appointed to supervise the preparation of said indices and that upon the completion thereof, all subsequent reports be immediately added to said indices as soon as final action of the Committee is taken thereon."

The sub-committee was appointed by the Chair as follows: Messrs. Cheney (Chairman), Heyl, Hexamer, Leclére and Wiegand.

The compilation of the Index, under the direction of the Committee, was completed in December, 1889, and by the Committee on Science and the Arts was reported to the Institute, and by the Institute referred to the Board of Managers, which directed its publication.

Provision has been made by the Secretary to index in like manner all subsequent reports, so that hereafter the record of the researches of the committee will readily be accessible.

Applications upon which, from lack of data or other reason, no report was made, are indicated in the Index by an asterisk (*). In such case, however, the records, which are accessible, will generally be found to contain a complete history of the case.

The compilation of this Index and the supervision of its publication were done by Mr. Percy A. Bivins, to whom the Committee's acknowledgments are due for the intelligent and thorough execution of the work.

THE COMMITTEE.

* The records of the names of applicants was so incomplete, that it was found impracticable to make an index of them as stated in the resolution. The indexing by names of the inventors is complete.

INDEX OF SUBJECTS.

INDEX TO APPLICANTS.

Call Lg

Entered at the Post Office at Philadelphia in accordance with Section 199 of the Postal Laws and Regulations.

VOL. CXXX. NO. 780.

THE JOURNAL OF THE FRANKLIN INSTITUTE

DEVOTED TO

Science and the Mechanic Arts.

Third Series. *DECEMBER, 1890.* VOL. C.—No. 6.

CONTENTS.

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MONTHLY, FIVE DOLLARS PER YEAR. SINGLE NUMBERS, FIFTY CENTS.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXX. DECEMBER, 1890. No. 6

THE PRODUCT OF THE EUREKA TEMPERED COPPER COMPANY.

[*Report of the Committee on Science and the Arts.*]

[No. 1,491.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, October 1, 1890.

The sub-committee appointed to examine and report upon application No. 1,491, made by the Eureka Tempered Copper Company, of North East, Erie County, Pa., dated April 21, 1890, and supplemented by their letter of August 7, 1890, beg leave to report:

That in the applications, as above, the applicants claim to possess processes invented by Almer Thomas and Luzerne Merket, of North East, Pa., in the first place, for casting pure copper without alloys, so as to make castings sound and free from blow-holes; and, in the second place, for hardening copper (after casting) without destroying its fibre or impairing its usefulness for electrical or other purposes. They also claim that no alloys are added to the cop-

per, and that the chemical composition of the castings is substantially the same as that of the ingot copper from which it was made.

As the processes in question (not having been patented) have not been described to your committee, we have, of necessity, confined our examination to the products of the applicants.

This examination has been made in three ways:

(1) Chemical analyses have been made of both the untempered and the tempered copper.

(2) Physical tests have been made, including tensile, transverse, compression and torsion tests of the untempered and of the tempered copper.

(3) Circulars have been sent to over 100 establishments in the United States and Canada, using tempered copper, asking for the results of their use of same, with any expression of opinion that they may see fit to give.

The results of these examinations have been made as follows:

(1.) Chemical analysis.

Dr. F. A. Genth, of this city, reports two sets of analyses of these coppers as follows:

	(1) Pig Copper. Per Cent.	*(2) Edge Pieces. Per Cent.*	*(3) Castings. Per Cent.*
Silver,	0·096	0·053	0·095
Copper,	99·890	99·961	99·914
Tin,	trace	0·045	0·094
Lead,	trace	trace	trace
Iron,	0·056	0·069	0·056
	100·042	100·128	100·159

	(1) Not Tempered. Per Cent.	*(2) Tempered. Per Cent.*
Silver,	0·026	0·025
Copper,	99·930	99·981
Tin,	none	none
Zinc,	none	none
Iron,	0·082	0·088
Aluminium,	none	none
Arsenic,	0·046	0·042
Phosphorus,	0·017	0·018
	100·101	100·154

The last two analyses were made from the same bar. No. 1 not tempered being made from the bar as cast by the processes of the applicants, but untempered; and No. 2 tempered being made after that bar had been tempered. It should also be mentioned that these same bars were used in the tensile tests described later on.

The above chemical examination shows that the examples are commercially pure copper, and thus substantiates the statement made to that effect by the applicants.

The principal tests were made by Mr. Tinius Olsen, of this city.

The diagrams, as made by his machine, are annexed to this report. The results, in figures, are also given on these diagrams. It is interesting to note how the tempered copper compares with the untempered copper in the first place, and in the second place how our tests compare with tests of ordinary commercial copper. It will be observed that the difference between the tempered and untempered copper is not very great; although, speaking generally the difference is in favor of the tempered samples.

As compared with such tests of ordinary commercial copper as the committee have been able to find, the difference is more marked. For example:

Untempered pieces broke at a strain per square inch of—

	Pounds.
(1),	23,180
(2),	24,410
Mean,	23,795

and the tempered pieces broke at a strain per square inch of—

	Pounds.
(1),	25,800
(2),	27,860
Mean,	26,830

It should be mentioned that there was a similar flaw in all of the above samples (due to piping from the shrinkage), which ran longitudinally on the edge of the pieces. Most of this faulty part had been removed when the samples

RECORD OF TESTS OF TEMPERED AND UNTEMPERED COPPER, MADE FOR THE COMMITTEE ON SCIENCE AND THE ARTS, AT THE TESTING ROOMS OF TINIUS OLSEN & CO., PHILADELPHIA.

Marked.		Size.	Area in Square Inches.	Broke at Lbs.	Strain per Square Inch in Lbs.	Limit of Elasticity in Lbs.	Limit of Elasticity per Square Inch in Lbs.	Elongation in Inches.	Elongation per Cent. of Original Length.	Area of Reduced Section In. Sq. In.	Reduction per Cent. of Original Section.	Memoranda.
Tensile,	B Tempered,	·858 ·752	·6452	16,650	25,800	7,400	11,460	·72	18·0	·4725	26·7	
	A Tempered,	·851 ·753	·6408	17,855	27,860	7,000	10,920	·94	23·5	·4060	36·6	
	B Untempered,	·853 ·755	·6440	14,930	23,180	6,550	10,170	·84	21·0	·4095	36·6	
	A Untempered,	·86 ·755	·6493	15,850	24,410	6,550	10,080	·90	22·5	·420	35·7	
Compression,	C Tempered,	·935 × ·938 1″ high	·8770	49,150	56,040	13,000	14,820	·28	28·0			
	E Tempered,	·938 × ·934 1·002″ high	·8761	46,500	53,070	12,400	14,150	·269	26·8			
	C Untempered,	·935 × ·937 1·002″ high	·8761	41,310	47,150	12,000	13,690	·275	27·4			
	E Untempered,	·935 × ·939 1″ high	·8779	45,300	51,600	14,000	15,940	·276	27·6			
Transverse,	D Tempered,	·938 ·941	·8826	Commenced permanent deflection at 820.				Deflect, 1″ at a load of 1,380 lbs.				Strain applied in centre of specimen on supports 12″ apart.
	F Untempered,	·94 ·942	·8854	Commenced permanent deflection at 500.				Deflect, 1″ at a load of 1,200 lbs.				
Torsion,	C Tempered,	·937	·6895	Yielded permanently at 120 lbs. Maximum load, 588 lbs. Ruptured after being twisted, 391°.								Measuring heads 2″ apart and strain recorded on 12″ leverage.
	E Untempered,	·937	·6895	Yielded permanently at 106 lbs. Maximum load, 557 lbs. Ruptured after being twisted, 600°.								

were cut in two lengthwise (for the purpose of having one-half of the piece sent to the applicants to be tempered). But a sample perfectly free from this piping would probably have given results somewhat higher than the above.

To compare the above figures with those of ordinary commercial copper, we submit herewith the results made on cast copper, by the United States Testing Board, and given in their report on *Iron, Steel and other Metals.* (Washington: Government Printing Office, 1878.)

Marks.	*Greatest Stress per Sq. In.*
1A,	14,180
1B,	11,340
30A,	29,200
30B,	26,400
51A,	14,546
51B,	20,440
52A,	16,940
52B,	21,600
53A,	18,800
53B,	9,200
57A,	26,000
57B,	29,820
Mean,	19,872 pounds per sq. in.

It thus appears that the untempered and the tempered copper have twenty per cent. and thirty-five per cent. greater tensile strength, respectively, than the average, as shown by the Government report.

In regard to the compression results (see diagrams herewith) are—

	Limit of Elasticity in Pounds.
Untempered (1),	12,000
(2),	14,000
Mean,	13,000
Tempered (1),	13,000
(2),	12,400
Mean,	12,700

The elastic limit of ordinary copper, according to Unwin (*Machine Designing*, D. Appleton & Co., 1877, p. 24) is 3,900

pounds, showing a great difference in favor of the samples tested by us.

As no figures for commercial copper, showing its tension and transverse strength, are available to the committee, we have been unable to make any comparisons showing the relative figures in these respects.

The result of the correspondence between the committee and various manufacturers, electric light companies, mill-wrights and other establishments, has been as follows:

In all fifty-three letters were received, in which a definite opinion was expressed. Of these, five were to the effect that the writer was unable to see any difference between the tempered copper and other metals and alloys. Eight parties had tried the copper, experimentally, for certain purposes, for which it evidently was unfit, such as for bits for rock drilling; as a substitute for tempered steel; for ammonia pump rods; for cauterization of blemishes in the limbs of horses; for nozzles for locomotive injectors when using certain saline waters, and so on.

Six expressed the opinion that the claims of the applicants were not substantiated by the experience of the writers.

Thirty-four expressed opinions, based upon their experiences, which were highly favorable to the tempered copper. Thus, it was stated that for bearings on coal-mining machinery it lasts much longer than any other metal before used; that it outlasts from three to four times the old style of commutator copper bars or brushes; very satisfactory for brasses on engine rods; bearings on dynamos run very cool and require but little lubrication; gives entire satisfaction on bearings of three threshing engines; in wrist-pin boxes and in cross-head; as step in gauge lathe, between end of spindle and set-screw is superior to hardened steel, brass, rawhide or wood, all of which were previously tried; very uniform in hardness and remarkably free from blow-holes; gave good results as a driving pinion in gear work; stood up well as armature bearing in street-car motors (a trying test), in small bearings, where the brass bearings would not last over sixty days the tempered copper has been nearly in a year, and is apparently in as good a condition as when first

put in. Many other extracts could be given, particularly from parties endorsing the copper for commutator brushes and segments, to which it seems particularly well adapted.

A number of specimens of castings are presented with this report, showing high excellence in quality and uniformity. Mechanical examination bears out the statements of the applicants as to the purity of their metal.

We believe that the claims of the applicants are substantiated by the experience of the majority of the parties using their copper, and also by our own investigations. We are of the opinion that the Eureka Tempered Copper Company has made a decided step in advance in the preparation of copper for many industrial uses, and we recommend the award to Almer Thomas and Luzerne Merket, of the JOHN SCOTT LEGACY MEDAL AND PREMIUM.

H. PEMBERTON, JR., *Chairman*,
LUTHER L. CHENEY,
NATHAN H. EDGERTON,
C. HANFORD HENDERSON,
RICHARD D. BAKER,
F. LYNWOOD GARRISON.

Adopted November 5, 1890.

H. W. SPANGLER,
Chairman of the Committee on Science and the Arts.

MANUFACTURE OF TIN-PLATE.

By F. Lynwood Garrison, Philadelphia, Pa.

[*Read at the Stated Meeting of the Franklin Institute, held Wednesday, November 19, 1890.*]

The process of manufacturing tin-plate, and indeed the character of the product appear to be something of a popular mystery which the public, in this country at least, is very slow in comprehending. Anything from a roof to a cup which happens to be made of tin-plate is called tin. It was gravely stated in a Western paper, some few months ago, that tin-plates were being extensively mined in the Black Hills, Dakota. Such ignorance is truly startling, and it would seem about time the public was informed that what is usually called tin, is simply sheet iron coated with from two to five per cent. of that metal, and that few or no articles of commerce are made of the pure metallic tin itself.*

When the iron sheets are coated with an alloy of tin, and from twenty-five to sixty per cent. lead, they are known as terne-plates, and have a dull leady appearance as compared with bright lustrous tin-plate. Terne-plates are usually used for roofing purposes, and are not infrequently sold as tin-plate pure and simple. When used for purposes other than the preservation or preparation of foods, terne-plate usually fulfils its requirements quite as well as tin-plate, and has the great advantage of cheapness.

History.—The manufacture of tin-plates seems to have originated in Northern Germany, but the particular place and year in which it was commenced are unknown.

Flower† states that it has been very clearly ascertained

* There seems to be a similar misconception as regards galvanized iron, which is simply iron coated with metallic zinc by being immersed in a molten bath of that metal. There does not seem to be any galvanic action whatsoever taking place during the operation, it is an alloying of the iron and zinc pure and simple.

† *History of Tin and Tin-plates*, P. W. Flower. George Bell & Sons: London, 1880.

that in 1620 the trade had already existed for many years in Bohemia. "In that year a knowledge of the manufacture was sought and obtained from Bohemia by the then Duke of Saxony, who immediately commenced the manufacture in his own territories, and it was from Saxony that the secret came to England in the year 1670." Works were first established at Pontypool, but, in consequence of certain difficulties were subsequently abandoned and neglected for a period of fifty years, and it was not until 1720, that the manufacture of tin-plate can be said to have been carried on to any extent.

Flower states that there appears to be no mention of the invention in any of the old French, German, or English works on metallurgy, and it seems to be probable that all information relating to this trade was kept very secret with a view to a quiet enjoyment of the monopoly by those who possessed a knowledge of its details. M. de Reaumur, writing in 1725, confirms this idea by saying that the art of making tin-plates was considered Germany's own trade.

The French iron-masters were not behind the English in introducing this industry into their country, the first successful works having been started in Mansvaux, in Alsace, in 1714, several years before the industry was thoroughly established at Pontypool. Two previous unsuccessful attempts were made to establish the industry in France, one at Chenessy, in Franche Comté; and the other at Beaumont la Ferrière, in Nivernois. The successful works started at Mansvaux, in Alsace, were followed by those of Bains, in Lorraine, in 1733; Imphy, near Nevers, in 1745, and Morambeau, in Franche Comté, in 1751.

Works were established near Forsmark, in Sweden, in the year 1739, English tin being imported for the purpose.

After the successful start, at Pontypool, in 1720, the manufacture began to extend itself through Wales, particularly in those places where water-power was available, and where forges already existed for the manufacture of charcoal iron.

From Pontypool it spread to Caerleon and Ponthir, in Monmouthshire, to Ynisgerwn near Neath, and Melin

Griffith near Cardiff, in Glamorganshire, and to Kidwelly and Carmathen Town, in Carmathenshire.*

For the past hundred years the manufacture of tin-plate in Great Britain has gradually increased until now she probably makes ninety per cent of the world's entire production, the rest coming from a few works in Germany and France.

In 1887, Germany produced 16,720 metric tons of tin-plate, basic steel being used almost exclusively for the purpose.†

It is an interesting fact that while the output of metallic tin from the Cornish mines has gradually decreased within the past twenty years (10,200 tons, in 1870, and 9,183 tons, in 1888), the production of tin-plate in Great Britain has increased at an enormous ratio. In 1889, Great Britain exported 430,623 tons, of which 331,312 tons went to the United States; the entire production, in 1889, was about 450,000 tons. The great bulk of the metallic tin consumed in Great Britain in the manufacture of tin-plate is imported —mostly from Malacca Straits and Australia. The same may be said for Germany and France, although some small amounts are still mined in the Zinnwald district in Bohemia.

A brief sketch in this connection of the history of the futile attempts to establish a tin-plate industry in the United States may not be without some melancholy interest to the patriotic American.

The very high prices of tin-plate which prevailed in our markets between 1873 and 1878 induced some enterprising persons to establish a small tin-plate works at Wellsville, O., in 1873. The quality of the plates made at these works was said to be excellent.‡ Between 1873 and 1875, tin-plates were also made to a limited extent, at Leechburgh, Pa. Owing to the fall in prices, in 1875, both of these works were obliged to shut down. In the meantime somewhat more

* Flower's *History of Tin and Tin-plates.* London, 1880.

† *Annual Report of American Iron and Steel Association,* 1890, p. 96.

‡ *A Treatise upon Tin-plate Manufacture in the United States,* by John Jarrett, p. 5.

extensive works were built at Demmler near Pittsburgh, Pa., and put in operation early in 1875. The career of these works as such was, however, short-lived, and since they were shut down there does not appear to have been a single pound of tin-plate made in the United States for commercial purposes.

For commercial purposes tin-plates are divided into two classes, what are termed charcoal-plates and coke-plates, according as charcoal or coke is used as fuel in the manufacture of the iron bars from which the plates are rolled. At the present time, however, by far the greater part of the plates are made of mild steel, usually open-hearth, either acid or basic. It seems, moreover, that these tinned steel sheets are not sold as such, but as tinned iron.

The iron sheets made with charcoal as fuel, are, as a rule, of much finer quality, and bring a better price than the coke iron or steel sheets.

As the methods used for the conversion of the raw ore or pig into these iron or steel bars belongs more particularly to the metallurgy of iron and steel, they need not be mentioned in this connection.

Rolling the Sheets.—The finished bars used in the manufacture of tin-plates vary in dimensions, according to the size and weight of the sheets required, or the manner of rolling.

After the finished bar has been sheared to the required size, it is heated to redness in a reverberatory furnace, and rolled; again heated, rolled, and doubled; heated a third time, rolled, and again doubled; then heated and rolled a fourth time. Sometimes the heating and rolling is continued six times. The length of the bar should be about an inch more than the width of the sheet to be made, so as to allow margin for shearing; the bar is therefore rolled with its axis parallel to the axis of the rolls.

When the plates leave the rolls they are called "finished," and are known as black plate, then when cool are trimmed and sheared as required.

Percy* states that the yield of black plate varies from

* *Metallurgy of Iron and Steel,* p. 726.

eighty to ninety per cent. of the iron used, the minimum yield being obtained from narrow plates rolled in one length and doubled three times, thus making eight sheets 10 x 14 inches, or doubled three times and rolled in two lengths, making sixteen sheets of 10 x 14 inches. The maximum yield is from wide plates doubled only once, and rolled into two lengths, thus making four sheets.

The more frequently a plate is doubled the greater will be the waste, owing to the larger amount of shearings cut off the extremities.

The weight of the ordinary sheets (lx and lxx, 10 x 14 inches, or 14 x 20 inches), is calculated in the following manner:*

Bars are selected of sufficient weight to produce sixteen sheets of 10 x 14, or eight sheets of 14 x 20 inches. Taking for example, 14 x 20-inch sheets, running 112 sheets per box, we have—

Weight when tinned, ...	150 pounds.†
Shear-house weight, ...	135 "

The yield of black plate in this variety is eighty-seven per cent. Then $\frac{135}{.87}$ pounds = 155 pounds, the weight of iron required to produce one box of these plates. As each bar of iron will make eight sheets, fourteen bars would be required for 112 sheets, hence $\frac{155}{14}$ = 11 pounds, the weight of one bar necessary to produce eight sheets of two lengths doubled twice. This formula will apply to a box of any weight of the same dimensions rolled in the same manner.

Black Pickling.—The plates are now pickled by being immersed in hot dilute sulphuric acid (one part acid to sixteen water), contained in lead-lined tanks. The sheets are placed on edge in a wooden rack made for the purpose, and the whole immersed in the acid. By means of a suitable mechanical arrangement, the rack holding the sheets is given a regular up-and-down motion, thus maintaining a circulation in the acid bath.

When all the scale or oxide has been dissolved off, the

* Percy's *Metallurgy of Iron and Steel*, p. 725, *et seq.*

† Taking 2,240 pounds to the ton.

rack holding the sheets is immersed, and the whole thoroughly washed several times in fresh water. The pickling and washing are carried on at the same time, and spare cradles are provided for filling and emptying, so that no delay occurs.

First Annealing.—The sheets are then dried, packed in tight annealing boxes or pots and annealed from twelve to twenty-four hours in a reverberatory furnace.

The temperature to which the plates are thus subjected is kept just high enough to prevent their softening to such a degree as to cause them to stick together when cold, *i. e.*, just below a good welding heat. The door of the annealing furnace is made level with the floor, so the annealing boxes can be readily wheeled in on a truck. The object of this annealing is to so soften the sheets that they will readily take a polish when cold rolled in the next operation. If the annealing has been properly done, the sheets come out nearly as soft as lead.

Cold Rolling.—In order to receive a proper coating of tin and possess a fine finish, it is necessary to pass the sheets singly through a series of highly-polished cold rolls. These rolls should be as hard as possible, have a high polish, be heavy, and set in strong solid frames. A well-polished surface saves tin, and is very essential to the good appearance of the finished plate. It might be stated in this connection that mild steel-plates always require less tin to coat them than iron, as the former is denser, and the tin has less opportunity to penetrate into the pores of the metal.

Second Annealing.—After the cold rolling the sheets become more or less harsh, and to remove this they are again annealed in the same way, but at a somewhat lower temperature than the first annealing. Ten hours is usually found sufficient for this purpose.

White Pickling.—The surface of the sheets having become somewhat oxidized by the cold rolling and second annealing, it is necessary to pickle them a second time. In this operation, which is known as the white pickling, a much weaker solution of sulphuric acid is used, or sometimes hydrochloric acid is used instead. The slight coating

of oxide or scale is thus quickly removed, and after being thoroughly washed with water, the sheets are supposed to be ready for the coating of tin. As a matter of fact, however, it is always necessary to examine them very carefully after removal from the annealing pots, and if they are rough and contain small specks or patches of undissolved oxide or scale, they will have to be scoured with sand and perhaps re-pickled.

The careful inspection and selection of the sheets is a most important part of the operation, requiring a considerable degree of skill and experience on the part of the workman. It is always better if the sheets can be inspected and the defective ones picked out at end of each of the several operations.

As the workmen are usually paid by the amount of work done, there is naturally a constant tendency for defective sheets to reach the "tin-man's" hands.

The hands required for each set of pots consists of a tin-man, a wash-man, a grease-boy and three girls, who rub, dust and polish the sheets.

The tin-man (foreman of the set that does the tinning) receives the sheets from the scourer and places them in a trough of water near at hand until he is ready to remove them to the grease-pot.

Grease-pot.—As the sheets are removed from the water trough, they are immediately plunged, sheet by sheet, into what is known as the grease-pot, which is filled with hot palm oil or tallow.

The object of the oil bath is to remove the moisture and to warm the sheet so as to prepare it for tinning.

Tin-pot.—After remaining in the hot grease some time, they are removed in parcels and plunged into the tin-pot containing a bath of molten tin covered with palm oil. Here they are allowed to soak for about twenty minutes, the tin-man constantly opening and re-opening the pack with his tongs, thus enabling the molten tin to get at every part of the surface. As a result of the soaking, the iron (or steel) absorbs a certain amount of tin on or into the surface of the sheets. It seems probable that an alloy is formed by

those portions of the two metals which come in close contact. A very large proportion of the tin is thus absorbed and held between the fibres of the iron, as after the pickling and annealing operations the surface of the iron is in a more or less spongy condition. If the tin were simply mechanically held or absorbed by the fibres or pores of the iron, it should be possible to liquate it out by simply heating the tinned sheet to a temperature slightly above the melting-point of tin—227°·8 C., or 458°·6 F. If we heat the tinned sheet to a temperature sufficient to volatilize the tin, and then examine it with a microscope, we shall find that a considerable part of the tin persistently sticks to the iron, and if we attempt to burn it out we shall burn the iron also. Of course, where there is a thick coating of tin, it is possible to melt off the outer layers that are not in direct contact with the iron.

Wash-pot.—When the sheets have soaked sufficiently, the tin-man removes them from the tin-pot and hands them to the wash-man, who plunges them in parcels into the wash-pot filled with tin, and allows them to remain there, to keep hot, until he is ready to use them. They are then removed in batches and placed upon a flat iron plate, called the hob. With a thick hempen brush in one hand and tongs in the other, the wash-man brushes the two sides of each sheet in order to remove the excess of tin which has collected between them. The wash-pot is generally divided into two compartments, one larger than the other. The sheets are first put into the larger compartment, which contains a better quality of tin than the tin-pot, and, as its temperature is comparatively low, the sheets can be kept in it a considerable length of time without becoming "dry."

To obliterate the marks left by the brush, and to give a polish to the surface, the sheets are dipped, one at a time, into the smaller compartment of the wash-pot.

Patent-pot.—Then without releasing the sheet from the tongs, it is passed between a pair of steel rolls into the "patent-pot." As soon as the sheet has passed through these rolls into the tin below, it is caught, moved along and raised by means of a cradle to meet another pair of rolls revolv-

ing in the surface of the tin bath, thus as one sheet is rolled into the bath of tin another is rolled out. The object of these rolls is to squeeze off the surplus tin and give the sheet a smooth, even surface.

The sheets are now placed in a rack to cool, after which they are taken by women and rubbed with saw-dust or bran to remove the grease, then polished with flannel or buckskin, and removed to the sorting-room. Here they are very carefully examined and classed according to finish and quality.

The tests of quality are ductility, strength and color; this when in a high degree requires that the iron or steel used shall be of the best quality, and that its subsequent manufacture into sheets and the tinning process through which they go shall be conducted with the greatest care and skill.

Some of the defective sheets, known as "menders," are returned to the tin-house for repair; others, known as "wasters," are sold on the market at a reduced price.

After the finished sheets are counted, they are packed in wooden boxes, which are carefully marked to indicate contents.

The use of the oil or grease is to preserve the tin and iron from the oxidizing action of the atmosphere. The chief object, however, of plunging the sheets in the grease-pot filled with heated oil, is to dry the moisture from the sheets, otherwise they would not take the tin so readily.

By melting a little tin or lead in a ladle, skimming off the dross and putting a little oil or grease on the surface of the molten metal, the effect of the grease in cleaning the surface will become evident. The palm oil comes mostly from the West Coast of Africa in large casks, holding about a half a ton. It varies in quality somewhat, a preference is given to what is known as "selected Lagos oil," which probably contains less dirt and water than the commoner sorts. Tallow would be equally well adapted for all practical purposes were it not for the very disagreeable smell resulting from its use.

It is interesting to notice something of the technical

development of the process of tinning since the year 1720, and for that purpose I have drawn largely from Flower's interesting little work on the *History of Tin and Tin-plates.* While Mr. Flower has been most thorough and careful in his historical treatment of the subject, it is to be regretted he so carefully avoids giving us anything of the modern technical details.

The old German method of tinning, as first used at Pontypool in 1720, was, of course, very crude and primitive in comparison to that of the present time.

The iron sheets were made by hammering from the bar or billet very much in the same way as the celebrated Russian sheet-iron is still made in the Urals.

The pickling was done in water acidified by the fermentation of barley meal or rye; in order to facilitate this fermentation it was necessary to place the tubs or vats in heated vaults, kept at a temperature of about 100° F. Such an acid solution being necessarily very weak, the process of pickling usually required from two to three days, and sometimes much longer. Vinegar was sometimes used for the purpose, but although stronger, it was doubtless too expensive a substitute for rye water.

Before pickling came into use, about 1747, the sheets were prepared by scouring with sand and water, and filing off the rough places, then covering them with resin before dipping into the molten tin.

Tallow or grease was used to cover the tin bath, but this produced at times such an unbearable stench that it ultimately led to the universal use of palm oil for the purpose. A little water was always added with the tallow to cause it to swell and foam. The grease or tallow always became better after being used a short time, as it seems to be a curious fact that any kind of empyreumatic fat is better for this purpose than fresh tallow or grease.

Before the rolls, for rolling the sheet out of the bath where it has its last dip (patent-pot), came into use, it was necessary to melt off the ridge or wire (list) of tin which collected on the lower edge of the sheet. For this purpose a shallow trough or pot of iron containing a bath of molten

tin about a half an inch deep was used. As soon as the ridge was melted off, the sheet was given a smart blow with a stick, which disengaged the superfluous metal, leaving only a faint streak where it was attached.

The most important improvements in the process seem to have followed each other at very long intervals, the first being in 1728, when the process of making the sheets by hammering was replaced by that of rolling. In 1745, the grease-pot for preparing the sheets for coating was first used and, in 1760, barley or rye-meal water was replaced by hydrochloric acid for the purpose of pickling. In 1783, grooved rolls for bar rolling were first used. The annealing-pot was invented by Thomas Morgan, in 1829. About 1865, the use of steel or iron rolls for rolling the sheet out of the last pot (patent-pot), became general, but from that date up to the present time, there seem to have been few or no innovations, although of course many improvements have been made in the original inventions.

About the year 1800, the idea of dividing the wash-pot into two parts seems to have been first suggested. The idea of it was simply to keep the scum (consisting chiefly of a mixture of dirt, tin oxide and grease) of the first compartment from getting into the better grade of tin used to finish the sheets in the second compartment. The necessity of skimming off the scum every time a fresh batch of sheets is put into the wash-pot is thus obviated.

The second compartment always contains the purest tin, and, as it becomes contaminated by the iron, is removed to the first compartment and finally to the tin-pot.

Before the patent-pot with its rolls came into general use, the sheets were finished by placing them in a grease-pot or bath of palm oil to "sweat off" the superfluous tin. They were first placed by the workman on a grate or basket between "pins," so-called, and removed by the grease-boy in rotation; as one sheet came out of the basket another went in, and the number of pins employed therefore regulated the time for remaining in the pot. The fewer the pins the shorter the time, and the heavier the coating, hence the longer they remained the barer the sheet.

It was usual to employ a grate of only five or six pins for charcoal sheets, while as many as up to thirty-five were employed for cheaper sheets.* The quantity of tin thus removed is about two or three times that left on the sheets.

By this arrangement the length of time the sheets remain in the pot can be regulated with considerable exactness; thus, when the temperature remains constant, the amount of tin removed or left on the sheets is regulated to a nicety.

In old times it was supposed that the addition of a very small amount of copper to the molten tin made it adhere better to the sheets. It was claimed that such an alloy possessed this quality, "because it is a medium fusibility between iron and tin." The use of the copper was known as the "secret" and "you must take care not to have either too much or too little of this secret."† The quantity of copper used seemed to depend equally upon the quality of the tin and of the iron. If too much copper is used the sheets do not look well; if, on the other hand, not enough, the sheets take too much tin. As a rule, two pounds of copper are used to 100 or 150 pounds of tin.

The idea seems to be prevalent in the United States that in order to establish a tin-plate industry in any country, it is requisite for such country to be a metallic tin producer. That such a thing is utterly wrong is, I think, fully demonstrated by the following figures:

It is stated in the official *Mineral Statistics of the United Kingdom of Great Britain and Ireland*, for the year 1889:

"The quantity of tin ore mined in Great Britain, in 1889, amounted to 13,809 tons, from which 8,912 tons of tin were obtained, against 14,370 tons of ore mined in 1888, yielding 9,241 tons of tin. The importations of tin ore and tin in 1889 amounted to 2,008 tons of ore and 30,093 tons of tin, against 2,406 tons of ore and 28,049 tons of tin in 1888."

It will thus be observed that the amount of metallic tin produced in Great Britain, in 1889, was less than one-third the amount imported. In other words, the great bulk of the

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* *History of Tin and Tin-plates*, p. 171, Flower, London, 1880.

† Flower, *History of Tin and Tin-plates*, p. 171.

tin used in this country, in the forms of tin-plate, is first imported into England from foreign countries, there made into tin-plate, and then exported to the United States for consumption.

We have of late years heard much of the large deposits of tin ore discovered in various parts of this country, but the writer has yet to see the first tangible evidences of their existence. It is true, tin ore in small and scattered quantities has been discovered in the Black Hills, S. D.; at Kings Mountain, N. C.; in Virginia, Georgia, Winslow, Me.; near the town of Jackson, N. H.; Booneville, Idaho, and at San Jacinto, San Bernardino County, Cal. With the exception of those in the Black Hills it cannot be said that any of these deposits have been explored or developed to any extent. According to recent reports, the deposits of San Jacinto, Cal., appear to be very promising.* There appears to be a great similarity between the rocks and geological features of this district and those of the tin-producing districts of Cornwall.

The tin ore deposits in the Black Hills have possibly been fairly well explored, but up to the present time this district appears to have been more productive of humbugs than tin ore.

Deposits of tin ore (stream tin) have been found in some parts of Mexico, but as they have not been explored to any extent we know little of them.

* *Engineering and Mining Journal*, Oct. 18, 1890, p. 450.

A REVOLUTION IN DYEING.

BY PROF. R. L. CHASE,
Pennsylvania Museum and School of Industrial Art.

[*A Lecture delivered before the Franklin Institute, January 13, 1890.*]

[*Concluded from vol. c, p. 391.*]

GREEN DYESTUFFS.

The discovery of green dyestuffs soon followed that of the violet. One of these, methyl green, being made by the action of methyl chloride on the base of methyl violet (pentamethyl-pararosaniline), and bearing a very close relationship to that dyestuff in its constitution. Another green called iodide green was made by treating Hoffman's violet with methyl iodide, while a third known as aldehyde green was prepared from aldehyde and magenta. All of these bear a close relationship to rosaniline and were the greens used up to the year 1877, when the method of making benzaldehyde green was discovered and, owing to its superiority, it has almost entirely displaced the other greens. This last is made in quite a number of ways and is usually sold as a salt of zinc chloride, forming fine green crystals easily soluble in water. It is used only for dyeing cotton and produces a very fine green shade as seen in the sample shown.

All these dyestuffs bear a striking relationship, and in most cases their behavior towards textile fibres is the same. With the exception of the blue, they all dye wool in a neutral bath, but are little used at present for this purpose. They are mostly used for cotton, which must first be mordanted before it will take the color. Cotton blue, however, will dye unmordanted cotton in a bath to which a little alum has been added and is mostly used in this way. Alkali blue is a peculiar dyestuff and is used entirely for wool in the following manner: The dye-bath is made up with the necessary amount of dyestuff and a small amount of an alkaline salt added. The wool is boiled in this and becomes colored a very slight blue. On washing the wool and immersing it in an acid bath the coloring matter is developed into a very fine blue.

Unfortunately none of this class of rosaniline dyestuffs produce fast colors and for this reason the artificial dyestuffs have obtained a bad name, which has clung to them in spite of the fact that later discoveries have changed this entirely, as we shall see later on. If we compare the formulæ of these dyestuffs we shall see how very similar they are in their constitution and how great a change is sometimes wrought by a very slight change in the constitution. Starting with rosaniline and a very similar compound pararosaniline we have:

Rosaniline.

$$C \left\{ \begin{array}{l} C_6H_3(CH_3)NH_2 \\ C_6H_4NH_2 \\ C_6H_4NH_2 \\ OH \end{array} \right.$$

Pararosaniline.

$$C \left\{ \begin{array}{l} C_6H_4NH_2 \\ C_6H_4NH_2 \\ C_6H_4NH_2 \\ OH \end{array} \right.$$

Magenta.

$$C \left\{ \begin{array}{l} C_6H_3(CH_3)NH_2 \\ C_6H_4NH_2 \\ C_6H_4NH_2 \\ Cl \end{array} \right.$$

Diphenylamine Blue.

$$C \left\{ \begin{array}{l} C_6H_4NH(C_6H_5) \\ C_6H_4NH(C_6H_5) \\ C_6H_4NH(C_6H_5) \\ Cl \end{array} \right.$$

Acid Magenta.

$$C \left\{ \begin{array}{l} C_6H_2(CH_3) \left\{ \begin{array}{l} NaSO_3 \\ NH_2 \end{array} \right. \\ C_6H_3 \left\{ \begin{array}{l} NaSO_3 \\ NH_2 \end{array} \right. \\ C_6H_3 \left\{ \begin{array}{l} NaSO_3 \\ NH_2 \end{array} \right. \\ OH \end{array} \right.$$

Spirit Blue.

$$C \left\{ \begin{array}{l} C_6H_3CH_3NH(C_6H_5) \\ C_6H_4NH(C_6H_5) \\ C_6H_4NH(C_6H_5) \\ Cl \end{array} \right.$$

Alkali Blue.

$$C \left\{ \begin{array}{l} C_6H_3CH_3NH(C_6H_5) \\ C_6H_4NH(C_6H_5) \\ C_6H_4N \left\{ \begin{array}{l} C_6H_4 \\ H \\ OSO_2 \end{array} \right. \end{array} \right.$$

Alkali Blue D.

$$C \left\{ \begin{array}{l} C_6H_4NH(C_6H_5) \\ C_6H_4NH(C_6H_5) \\ C_6H_4N \left\{ \begin{array}{l} C_6H_4 \\ H \\ OSO_2 \end{array} \right. \end{array} \right.$$

Methyl Violet 2B.

$$C \left\{ \begin{array}{l} C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2 \\ C_6H_4NHCH_3Cl \end{array} \right.$$

Benzyl Violet.

$$C \left\{ \begin{array}{l} C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2 \\ C_6H_4N(C_7H_7)CH_3Cl \end{array} \right.$$

Acid Violet.

$$C \left\{ \begin{array}{l} C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2 \\ C_6H_4N(C_7H_6NaSO_3)CH_3 \\ OH \end{array} \right.$$

Malachite Green.

$$C \left\{ \begin{array}{l} C_6H_5 \\ C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2Cl \end{array} \right.$$

These few formulæ will give a good idea of the possibilities of organic chemistry in this direction.

Although these dyestuffs are not used for wool, yet in each case a corresponding sulpho compound can be made which will dye wool in an acid bath. In this way we now have acid magenta, acid violets, and acid greens all used for wool and not applicable to cotton as is seen on the sample sheet shown.

Very closely allied to this class of dyestuffs is another consisting of three members and containing a naphthyl group. These are the victoria blues, B, 4R, and night blue. The first is the hydrochloride of tetra-methyl phenyl triamido alpha-naphthyl diphenyl carbinol and from its very long name chemically it is easily seen why it is given a different name in commerce.

The compound containing a para tolyl group instead of phenyl is night blue while the penta-methyl phenyl tri-amido compound is the 4R shade.

Victoria Blue B.

$$C \begin{cases} C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2 \\ C_{10}H_6NHC_6H_5Cl \end{cases}$$

Night Blue.

$$C \begin{cases} C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2 \\ C_{10}H_6NH(C_7H_7)Cl \end{cases}$$

Victoria Blue 4R.

$$C \begin{cases} C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2 \\ C_{10}H_6NCH_3C_6H_5Cl \end{cases}$$

These dyestuffs are used for wool, and produce very fine shades, which are quite fast to soap, but have the serious fault of rubbing off or crocking.

AURAMINE.

In the dyestuffs so far mentioned, we notice that there is not one that produces a yellow color, and the demand for a yellow that will dye mordanted cotton in connection with these basic dyestuffs for a long time remained unfilled. In 1875 a dyestuff giving a yellowish red color was discovered, but it was not until nearly ten years later that a satisfactory bright yellow was obtained. At that time a new dyestuff, called auramine, was discovered, and on mordanted cotton produces shades of very bright yellow, which are quite fast to both light and soap. Although it does not belong to the basic aniline group of dyestuffs, yet as it is used almost entirely with them, it is mentioned here. It is made by treating dimethyl aniline with carbon oxychloride in the presence of aluminium chloride. When this product is treated with ammonium and zinc chloride, the base of auramine, imido tetra-methyl di-amido di-phenyl methane, is obtained, and its hydrochloride is auramine.

$$C \begin{cases} C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2 \\ NH \end{cases}$$

SAFRANINE.

This is a red coloring dyestuff, and produces very bright shades on mordanted cotton, and is also sometimes used for light pinks on wool. The dyestuff can be made in quite a

number of different ways, and is used to a considerable extent in connection with those already mentioned.

NITRO COMPOUNDS.

There are several important dyestuffs belonging to this class, the principal ones being picric acid and naphthol yellow.

PICRIC ACID.

This is made by the action of nitric acid on phenol-sulphonic acid, and is a tri-nitro phenol. It forms yellow crystals, which dye wool or silk in an acid bath a very fine greenish yellow. It was formerly much used, but has now been largely replaced by naphthol yellow S.

NAPHTHOL YELLOW.

This corresponds very closely to the above, and is the nitro compound of alpha-naphthol. It dyes wool a fine yellow, which, however, volatilizes at a moderate heat, and is not at all fast, and has now been superseded entirely by the sulpho compound.

NAPHTHOL YELLOW S.

This is often sold as naphthol yellow, acid yellow, etc. It a salt of dinitronaphthol-sulphonic acid, and dyes wool in an acid bath a pure yellow, which is only moderately fast to light and soap.

THE PHTALEIN DYESTUFFS.

By the action of phtalic acid or anhydride on phenols, bodies called phtaleïns are formed, and one of these, the anhydride of resorcinol phtaleïn, is known as fluoresceïn, and is made by heating three parts of phtalic anhydride with four of resorcinol.

Fluoresceïn.

$$C_6H_4 \left\{ \begin{matrix} COC_6H_3OH \\ COC_6H_3OH \end{matrix} \right\} O$$

By substituting various radicals in this compound the so-called eosine dyestuffs are produced.

The sodium salt of the tetra-brom compound is known as eosine B, and gives yellow shades of pink on wool, while the sodium salt of tetra-iodo fluoresceïn is erythrosine B, and affords bluer shades.

Eosine B.

$$C_6H_4 \left\{ \begin{matrix} COC_6HBr_2ONa \\ COC_6HBr_2ONa \end{matrix} \right\} O$$

Erythrosine B.

$$C_6H_4 \left\{ \begin{matrix} COC_6HI_2OK \\ COC_6HI_2OK \end{matrix} \right\} O$$

In both these compounds the substitution has been in the resorcinol group, but compounds also exist in which the substitution is in the C_6H_4 group of the phtalic acid residue.

PHLOXINE.

To this class phloxine belongs and it is the potassium salt of tetra-bromo-dichloro-fluoresceïn.

$$C_6H_2Cl_2 \left\{ \begin{matrix} COC_6HBr_2OK \\ COC_6HBr_2OK \end{matrix} \right\} O$$

ROSE BENGAL.

This also belongs to this class and is the tetra-iodo-dichloro-fluoresceïn.

$$C_6H_2Cl_2 \left\{ \begin{matrix} COC_6HI_2OK \\ COC_6HI_2OK \end{matrix} \right\} O$$

RHODAMINE.

This is a comparatively recent dyestuff and is obtained in an entirely different way from those already mentioned. It belongs to the amido class of dyestuffs, and is prepared by heating one molecule of phtalic anhydride with two of diethyl-meta-amido-phenol, and it has the constitution expressed by the following formula.

$$C_6H_4 \left\{ \begin{matrix} COC_6H_3 \\ \\ COC_6H_3 \end{matrix} \right. \left\{ \begin{matrix} N^m(C_2H_5)_2 \\ O \\ N(C_2H_5)_2 \end{matrix} \right.$$

All of these dyestuffs are used to produce pink shades

on wool, and are dyed in a weak acid bath as a rule. With the exception of rhodamine, the shades produced are extremely fugitive and a few hours' exposure is sufficient to cause a change.

Rhodamine produces shades which are quite fast to light, and also to soap, and is in every way a dyestuff far superior to the others.

THE AZO DYESTUFFS.

A very large class of dyestuffs, comprising a number of divisions is what are known as the azo dyestuffs. These comprise by far the largest number of artificial dyestuffs and the number is greatly increased every year. It is in this field that the greatest amount of work is being done at the present time, and many of our most important dyestuffs belong to this class. Although these differ very much and are divided into a number of subdivisions, yet they are all similar in one respect, and that is in containing the group $—N=N—$

Azo benzene is the type of one of these compounds in which both the affinities of the nitrogen group have been satisfied with a phenyl group and we have for this compound the symbol

$$C_6H_5—N=N—C_6H_5$$

If the second affinity is satisfied by an acid or basic radical compounds are formed called diazo compounds and from these a large number of dyestuffs have been made.

AMIDO AZO DYESTUFFS.

These were the first of these dyestuffs made and one of their number, aniline yellow, was discovered as early as 1859 and by 1863 was a commercial product. It is not now used, but two members of the class are used quite extensively at the present time in cotton dyeing.

BISMARCK BROWN.

This is the hydrochloride of triamido-azo benzene,

$$C_6H_4(NH_2)NNC_6H_3(NH_2)_2 2HCl.$$

It was discovered in 1867 and is a dark brown powder,

which dyes a reddish brown shade. It is extensively used in dyeing leather and also cotton in connection with the natural dyestuffs

CHRYSOIDINE.

This was not discovered until 1875 and is the hydrochloride of diamido azo benzene,

$$C_6H_5NNC_6H_3(NH_2)_2HCl.$$

It dyes very similarly to the previous dyestuff and produces shades which are much yellower than those produced by the brown. The fastness of their shades seems to depend on the number of amido groups present, Bismarck brown being faster than chrysoidine and this in turn faster than aniline yellow which contains but one amido group.

These dyestuffs will color wool in a neutral bath but at the present time are never used for this purpose. But there are corresponding sulphonated compounds which will dye wool in an acid bath and these are used to some extent.

The principal representatives of this class are fast yellow G, derived from aniline yellow, dimethyl aniline orange, also known by various other names as orange No. 3, tropæolin D, metanil yellow, etc.

OXYAZO DYESTUFFS.

Nearly all the so-called acid colors on wool are obtained by the use of dyestuffs belonging to this class, and various shades of yellow, orange, scarlet, red, brown and finally black are possible by the use of these dyestuffs alone. Violet, blue and green dyestuff do not occur, however, and render the series incomplete, and for these we are obliged to use other dyestuffs, as acid violet, victoria blue, indigo extract, acid green, none of which yield as fast shades as the oxyazo dyestuffs. These have only been in use a comparatively short time, and since the publication, in 1878, of a scientific investigation of these compounds by Greiss, their manufacture has developed wonderfully, so that at the present time, the manufacture of the various azo dyes is the most important of all.

The great number of these dyestuffs is due to the fact that every primary aromatic amine, when converted into a diazo compound, will combine with almost any phenol or derivative of a phenol to form an azo dye. As most of these are insoluble in water, the sulphonated body is formed and the dye brought into use as a sodium sulphonated compound.

The principal amines used in the manufacture of these dyes are aniline ($C_6H_5NH_2$), toluidine ($C_6H_4CH_3NH_2$), xylidine ($C_6H_3NH_2(CH_3)_2$), alpha and beta-naphthylamine ($C_{10}H_7NH_2$) and also sulphanilic and naphthionic acids ($C_6H_4(HSO_3)NH_2$) and ($C_{10}H_6(HSO_3)NH_2$).

These can be combined with phenolic compounds as phenol (C_6H_5OH), resorcin ($C_6H_4(OH)_2$), alpha and beta-naphthol ($C_{10}H_7OH$), mono and di-sulphonic acid derivatives of the two last ($C_{10}H_5OH\ (HSO_3)_2$), etc.

While these give rise to a large number of dyestuffs, yet the number is still more increased by a property some of these possess of being diazotized and combined with other phenols giving rise to secondary azo compounds, called tetrazo dyes. These contain the group — N = N — twice, and these dyes as a rule afford faster shades than the ordinary azo dyes. Another class of the tetrazo dyes are the di-azo compounds, in which phenols, like resorcin ($C_6H_4(OH)_2$), combine with more than one molecule of a di-azo compound.

OXYAZO DYES.

As an example of this class we will take fast red. This is made by diazotizing ethyl xylidine naphthionic acid and combining it with beta-naphthol.

$$(NaSO_3)C_{10}H_6—N=N—C_{10}H_6OH.$$

Fast Red.

Among the best known of this class of dyestuffs we have the following: Archil substitute, a derivative from naphthionic acid; various scarlets, as scarlet R and 2R, cochineal scarlet 2R; fast red, bordeaux, amaranth, etc.

TETRAZO DYESTUFFS.

Scarlet.

Among the best known of the secondary azo compounds of this class are the Biebrich and croceïn scarlets, which have met with extensive use for both wool and cotton.

Brown.

Of the fast browns there are several representatives in the different acid browns.

One representative of these is the fast brown of Bayer, which has the following constitution:

$$C_6H_2(OH)_2 \begin{cases} NNC_{10}H_6(SO_3Na)\beta \\ NNC_{10}H_6(SO_3Na)\beta \end{cases}$$

Black.

Among recent discoveries in this class of tetrazo dyestuffs, that of several black dyes is to be noticed. One of these is naphthol black, and results from the action of salt R on diazotized amido azo naphthalene-disulphonic acid, and has the following constitution:

$$C_{10}H_5(SONa)_2NNC_{10}H_6NNC_{10}H_4(OH)\beta(SO_3Na)_2.$$

Another wool black is produced by the action of diazotized amido-azobenzene-disulphonic acid on paratolyl-beta-naphthylamine, and has the formula:

$$C_6H_4(SO_3Na)NNC_6H_3(SO_3Na)NNC_{10}H_6NH(C_7H_7).$$

These produce a fine black on wool from an acid bath, and are therefore much more simple to apply than a logwood black, which requires two baths. In time these will probably prove serious competitors to logwood black.

THE BENZIDINE DYESTUFFS.

These are tetrazo dyestuffs of a peculiar nature, and have been in use but a very short time, as the first one was only discovered in 1883, and it was not until several years afterward that this class became of industrial importance. They possess the peculiar property of dyeing unmordanted cotton and will also dye wool, although their use is largely confined

to cotton dyeing. Previous to their discovery, there were a few of the artificial dyestuffs used for coloring unmordanted cotton, and, as alum was usually added to the bath, these were commonly spoken of as the alum colors, this term color unfortunately being applied indiscriminately to the dyestuff as well as to the color produced by it. Cotton blue, chrysoidine, Bismarck brown and croceine scarlet and orange being the principal dyestuffs so used, but in each case the colors produced were not fast to washing. Indeed, it was thought impossible by many that any dyestuff would ever be discovered which would possess the advantages of dyeing cotton directly and also produce quite fast colors. This has been accomplished in these new dyestuffs, however, and we now have a large number with which nearly every shade can be produced.

CONGO RED.

This was the first discovered, and, as it was derived from benzidine, this name has been commonly applied to the whole class, although a large number are obtained from other compounds. Taking Congo red as a type, let us see how it is made. Benzidine has the formula

$$\begin{matrix} C_6H_4NH_2 \\ C_6H_4NH_2 \end{matrix}$$

and if this is diazotized a tetrazo compound is obtained whose hydrochloride has the formula

$$\begin{matrix} C_6H_4N = N - Cl \\ C_6H_4N = N - Cl \end{matrix} + 2C_{10}H_6(SO_3NO)NH_2 =$$

$$2HCl + \begin{matrix} C_6H_4N = NC_{10}H_5NH_2SO_3Na \\ C_6H_4N = NC_{10}H_5NH_2SO_3Na \end{matrix}$$

By combining this as before with aromatic phenols or amines, coloring substances are obtained, and if, in the above instance, napthylamine sulphonate of soda is used, congo red is obtained.

Benzidine can be produced from nitro benzene by treatment with caustic soda and zinc dust, boiling and treating the product with chlorhydric acid. The amido groups are

in the para position. Besides the dyes derived from benzidine there are others derived from a homologous base, tolidine, obtained from nitro toluidine. Among others, benzopurpurine and azo-blue are derived from this.

Another series, as Hessian purple, etc., come from still another base, obtained by treatment of a sulphonated para nitro-toluene, with caustic soda and zinc dust, as before, giving rise to diamido stilbine disulphonic acid, which, when diazotized in a chlorhydric acid solution, gives the dichloride of tetrazo stilbine di-sulphonic acid.

$$\left\{\begin{matrix} CHC_6H_3(SO_3H)\,NH_2 \\ CHC_6H_3(SO_3H)\,NH_2 \end{matrix}\right. + 2HNO_2 = \left\{\begin{matrix} CHC_6H_3SO_3HNNCl \\ CHC_6H_3SO_3HNNCl \end{matrix}\right.$$

The action takes place in two stages, so that one phenol can be used for the first part another or an amine for the second, and in this way we are able to get a very large number of dyes from each of the bases mentioned.

Congo corinth is an example of a dye of this type, and is made by the action of one molecule of tetrazo di-phenyl di-chloride with one molecule of sodium alpha-naphthylamine sulphonate, and treating the intermediate product with sodium alpha-naphthol-sulphonate.

$$\left\{\begin{matrix} C_6H_4NNC_{10}H_5 \\ C_6H_4NNCl \end{matrix}\right.(SO_3Na)^{a}NH_2^{a} + C_{10}H_6(SO_3Na)^{a}OH^{a} =$$

$$HCl + \left\{\begin{matrix} C_6H_4NNC_{10}H_5(SO_3Na)^{a}NH_2^{a} \\ C_6H_4NNC_{10}H_5(SO_3Na)^{a}OH^{a} \end{matrix}\right.$$

From what has been stated, it is readily seen that, taking any particular base as benzidine, there are two dyestuffs possible for every two phenols used, and the same for every two amines, and by combinations of the four there are at least eight possible compounds, so that the number of these dyestuffs is being added to constantly.

Among the principal ones derived from benzidine we have chrysamine, congo red, delta purpurine G, congo corinth, benzo-azurine, R, G and 3G. From toluidine we have chrysamine R, benzo purpurine B, 4B, 6B, delta purpurine 5B, diamine red 3B, rose azurine G and B, congo corinth B, brilliant congo R.

From diamido stilbine come Hessian yellow, red, purple, violet.

These dyestuffs supply a long-felt want, and are now being extensively used for cotton and merino dyeing. For some shades they are now cheaper to use than the basic aniline dyestuffs, as the cost of labor is much less, and no doubt in time the basic dyestuffs will be largely supplanted by their improved rivals.

ANTHRACENE COLORING MATTERS.

These constitute a somewhat limited number of dyestuffs, some of which are, however, of the greatest industrial importance. They resemble each other in many of their properties, being insoluble in water and forming lakes with metallic salts. They are weak acid bodies and only dye by use of a mordant and with chromium mordants the shades are faster than any of the coal-tar colors so far mentioned, and also as fast as the fastest natural dyestuff colors. The number of these dyestuffs is also being gradually increased by new discoveries, so that at the present time we are able to produce all shades by the use of these dyestuffs alone. The first to be discovered was alizarine in 1868 by Graebe and Liebermann, but it did not come into general use for some years, due to its high cost and the difficulties attendant to the introduction of an artificial product. Commercial alizarine is a mixture of a number of very similar compounds, each of which produces its own particular shade but the difference is in degree and not in kind, so that we can consider them together. Anthracene occurs in the higher boiling products of coal-tar and is the starting point for the manufacture of alizarine. There are a number of methods of manufacture, one of which is to treat the anthracene with potassium bichromate and sulphuric acid and anthraquinone is formed, which when treated with strong sulphuric acid (fifty per cent. anhydride), gives the monosulphonic acid compound. The sodium salt of this compound, when fused with caustic soda in the presence of $KClO_3$ or KNO_3 to prevent reduction, gives sodium alizarate, which last on treatment with an acid gives free alizarine.

Anthracene. *Anthraquinone.*

$$C_6H_4{}^{CH}_{CH}C_6H_4 \qquad\qquad C_6H_4{}^{CO}_{CO}C_6H_4$$

do. Na. monosulphonate.

$$C_6H_4{}^{CO}_{CO}C_6H_3SO_3Na$$

Reaction to form sodium alizarate

$$C_6H_4{}^{CO}_{CO}C_6H_3SO_3Na + 3NaOH = C_6H_4{}^{CO}_{CO}C_6H_2(ONa)_2$$

If anthraquinone is treated with an excess of sulphuric acid, two disulphonated compounds are produced, alpha and beta, which when treated as before yield the two trioxy compounds flavo and anthra purpurine. These give yellower shades than pure alizarine and the commercial alizarine for red consists largely of these two substances.

Purpurine is another isomeric trioxy compound and is the natural coloring matter found, together with alizarine, in the madder root. When alizarine was first made it was claimed to be the same substance as that obtained from the madder root but the dyers were not able to obtain exactly the same results with it and for some time the reason for this was unknown but fuller investigation proved that the two were not identical but differed as stated above. Commercially, alizarine is sold in the form of a paste containing twenty per cent. of dry alizarine. Its present price is nineteen to twenty cents a pound and at this price it is not more than one-fourth as expensive as madder when the amount of color produced is considered. For many years, however, it sold for over a dollar a pound and at this price could not come into common use.

It is now almost universally used for all fast shades in which a red coloring matter is needed and has largely superseded the use of the natural red woods. By the use of different mordants a variety of colors can be obtained, as shown in the dyed samples. The most useful and generally used mordant for this class is bichromate of potash and the shades thus produced are exceedingly fast.

ALIZARINE ORANGE.

This is obtained directly from alizarine by treating its solution in petroleum spirit or glacial acetic acid with nitric acid, when beta-nitro alizarine, the alizarine orange of commerce, is produced. On wool, mordanted with alumina, very fine orange shades are produced, while on a chrome preparation the shade is a reddish brown. It is also used in cotton printing but its chief interest is that it is the intermediate product in the manufacture of alizarine blue.

ALIZARINE BLUE.

This is produced from alizarine orange by treatment with glycerine and sulphuric acid whereby a dihydroxy anthraquinone quinoline is produced, which is alizarine blue. It possesses both acid and basic properties and is entirely insoluble in water and as it will not remain in suspension like alizarine much inconvenience was experienced in its use. By treatment with bisulphite of soda a soluble compound is formed which is not affected by calcium or magnesium salts, or by weak acids. It is decomposed when heated above 70° C., so that when fixed on the fibre and heated above this point the insoluble compound is precipitated. This substance is now being extensively used in wool dyeing and is proving a formidable rival to vat blue. It is being extensively tried in Germany in connection with others of this class for army and police cloths.

Alizarine blue was patented in 1878 and was first introduced about 1880.

ALIZARINE BROWN.

$$C_6H_4 \genfrac{}{}{0pt}{}{CO}{CO} C_6H\,(OH)_3, \left(\overset{\alpha'}{OH} \,.\, \overset{\beta'}{OH} \,.\, \overset{\beta^2}{OH}\right)$$

This is one of the five known isomers of trihydroxy anthraquinone, four of which are coloring matters. It is not obtained from anthracene, but from the action of pyrogalic acid on phtalic anhydride, in the presence of sulphuric acid or zinc chloride.

$$C_6H_4 \genfrac{}{}{0pt}{}{CO}{CO} O + C_6H_3(OH)_3 = C_6H_4 \genfrac{}{}{0pt}{}{CO}{CO} C_6H(OH)_3 + H_2O$$

Also by the action of gallic acid on benzoic acid in the presence of sulphuric acid.

$$C_6H_5COOH + C_6H_2(OH)_3COOH =$$

$$C_6H_4{}^{CO}_{CO}\,C_6H(OH)_3 + 2H_2O$$

This forms the essential constituent of commercial alizarine brown. It has been in use only a few years (having been introduced in 1886 by the Badische Company), and is dyed on wool prepared with bichromate of potash, and gives very fine shades. Its price at present prevents its use in many cases, although it is being used to a considerable extent for certain classes of work. In time it will probably prove a serious competitor to the compound browns at present used.

ALIZARINE BLACK.

This comes in the form of a paste, whose principal constituent is the bisulphite compound of napthazarine. On chromed wool it produces all shades, from a gray to a black, according to the amount used. For light gray shades it is very useful, but at its present price it cannot compete with the other blacks.

It has been introduced only some three years (1887).

GALLOFLAVINE.

This is a yellow dyestuff which was also introduced but a few years ago (1886, Badische). It yields quite bright shades of yellow on chromed wool.

ALIZARINE GREEN.

In 1888 it was discovered that alizarine blue, treated with sulphuric acid or anhydride would yield a number of products, some of which have been introduced commercially as dyestuffs.

Alizarine green and alizarine indigo blue are both made in this way, and the first yields shades of a bluish green, while the second gives shades very similar to those produced by vat indigo. At the present time these dyestuffs are rather expensive, owing to the roundabout method by

which they are produced, but if a more direct and cheaper method of making them is discovered, they will, no doubt come into very general use.

Besides these dyestuffs, which are directly related to anthracene, we also have a few others derived from pyrogallic acid and whose constituents are still unsettled. These dye similarly to those of the anthracene group, and may in fact belong to that class of dyestuffs, but so far they have not been fully investigated, and it is not known fully just where they belong chemically.

GALLEIN.

This is made by heating pyrogallic acid and phtalic anhydride to 200° C. and dissolving the product in sodium carbonate and then on treatment with acid the coloring matter is precipitated.

$$C_6H_4 \begin{matrix}CO\\CO\end{matrix} O + 2C_6H_3 \left\{\begin{matrix}OH\\OH\\OH\end{matrix}\right. + O =$$

$$C\left\{\begin{array}{l} C_6H_2\left\{\begin{array}{l}OH\\ O\\ O\end{array}\right. \\ \qquad\quad \left.\begin{array}{l}O\\O\\O\end{array}\right\} \\ C_6H_2\left\{\begin{array}{l}O\\ O\\ H\end{array}\right. \end{array}\right. + 3H_2O$$

$$\begin{array}{c}C_6H_4CO\\ O'\end{array}$$

The dyestuff comes in the form of a paste and on chromed wool gives a very fine purple shade.

The dyestuff is also sometimes called anthracene violet, alizarine violet, etc.

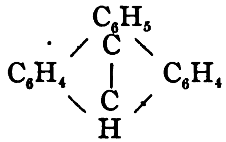
COERULEIN.

This is made from the above by treatment with strong sulphuric acid and the dyestuff thus produced is a black precipitate nearly insoluble in water. By treatment with reducing agents in an alkaline solution coeruleïn, the phtaleïn of coeruleïn, is formed and this can be used in dyeing similarly to the indigo vat. By treatment with a bisulphite, coeruleïn is converted into a soluble compound which will

dye chromed wool a very fast green and which can also be used in cotton printing.

The constitution of coeruleïn is not fully known but it is supposed to be a derivative of phenyl anthracene and if so belongs to the anthracene dyestuffs.

Phenyl anthracene.



Coeruleïn.

$C_{20}H_8O_6$

THE ARTIFICIAL VS. NATURAL DYESTUFFS.

The earlier artificial coal-tar dyestuffs produced shades so much more beautiful than those produced with the natural dyestuffs that, at first, the accompanying lack of permanency was not so much considered. As time went on, however, there was a reaction, and a demand for fast and bright colors arose, and at the present time the tendency is to discard very fugitive coloring matters and replace them by those that are fast or fairly so. The acid azo compounds were a great advance over those previously used, and many of them are as fast or faster than many of the natural coloring bodies. It was not, however, until the discovery of the anthracene series that fast shades of every color were made possible, and not only are these as fast as the natural dyestuffs, but they are far superior in point of brightness. One great advantage in the use of the artificial dyestuffs is that in each group of those dyed in the same way we have those which will produce the three primary colors, so that, by proper combination, all shades can be produced in one dyeing operation. As the natural dyestuffs do not possess this advantage, and many of the shades produced by them require two or more dyeing operations, the result has been that they have been largely displaced by the artificial products and only those which present some special advantages meet with any extensive use. Principally among these are logwood, fustic, indigo and cutch, all of which are used in enormous quantities; but even now the first and last have

strong competitors in the artificial dyestuffs, and it is not impossible that in time all the natural coloring matters may be entirely superseded.

MANUFACTURE OF THE ARTIFICIAL DYESTUFFS.

Since the discovery of the first artificial coal-tar dyestuffs, the manufacture of these products has grown constantly, until now it is an industry of great magnitude and importance. In this country, there are several places where this manufacture is carried on, but as a rule the number of dyestuffs made in any one place is somewhat restricted, and in some cases the entire product is confined to a very small number, as magenta, cotton blue, etc. In England, France, Germany, and some other countries, but especially in Germany, this industry has attained its greatest growth, and in some cases the works are so large as to resemble a small town or village. To show this more clearly, the following statistics are given of the size of one of these works, that of the Farbwerke, at Hoechst-on-Main, as given in their report of the celebration of their twenty-fifth anniversary in 1888.

They employ 1,860 workmen, fifty foremen, nine engineers, besides eighty-six clerks and fifty-seven chemists. The works cover an area of 726,000 square yards, and from one end of the works to the other the distance is 3,300 feet. Besides a great variety of dyestuffs, the acids used in their production are also manufactured, and the production for one year was as follows:

Kilograms of sulphuric acid, ...	23,108,000
Kilograms of other acids, ...	12,800,000
Kilograms of coal-tar products, ...	3,624,000

Statistics of other works are not at hand, but the above will give a good idea of the enormous size to which some of them have grown. Another important company—the Badische—has works at Ludswigshafen, Stuttgart, Neuville and Moscow.

All the foreign dyestuff manufacturers are represented by agents here, and enormous quantities of dyestuffs are imported yearly. With the exception of alizarine, these

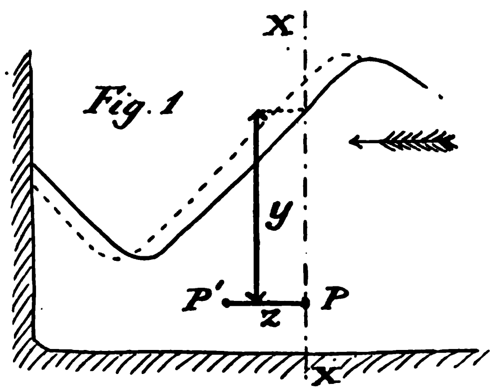
have to pay quite a heavy duty, so that possibly some time we may be able to manufacture more of these products here and more nearly supply our wants than is the case at present.

In concluding this lecture, I desire to express my thanks to the different dyestuff firms of this city for their kindness in supplying their latest productions, and in this way making it possible to bring to your attention some products which have not yet come into general use.

A NEW THEORY OF THE PROPAGATION OF WAVES IN LIQUIDS.

By L. D'AURIA.

While a wave is propagated in a liquid, the particles of the liquid which at a given instant are on any given vertical plane $X\,X$ (*Figs. 1* and *2*), perpendicular to the direction of



the propagation, will, at the next instant, be found displaced to one side, or to the other, of such plane; and the volume of liquid thus displaced, which we indicate by $\delta\,Q$, will be either added to, or subtracted from, the volume Q of the wave, which at the given instant is confined between the plane $X X$, and the abutment to the wave propagation.

Let v, represent the velocity of propagation; γ, the weight of one cubic foot of liquid; and g, the acceleration

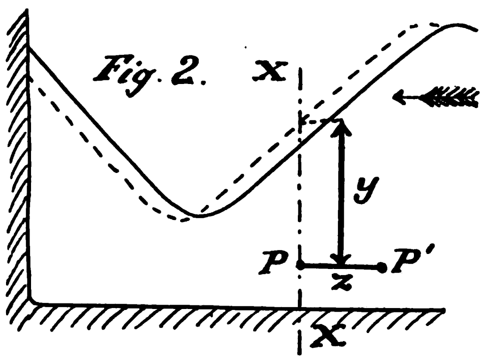
of gravity. The amount of energy which the variation of volume δQ implies is

$$E = \frac{v^2}{2g} \gamma \delta Q$$

On the other hand, if we denote by z, the horizontal displacement $P P'$ of a liquid particle P, at the depth y, below the surface of the wave, right on the plane $X X$, the work which the displacement z, implies is $\gamma z y dy$; and the work implied in the displacement δQ will be

$$W = \gamma \int_0^h z y dy$$

in which h represents the whole depth of the liquid to



which the displacement z is extended. This work must equal the energy E, at every instant, hence it follows

$$v^2 = \frac{2g}{\delta Q} \int_0^h z y dy \tag{1}$$

Now, in regard to z, we can put $z = f(y)$; and observing that

$$\delta Q = \int_0^h f(y) dy$$

we can write

$$v^2 = 2g \frac{\int_0^h f(y) y dy}{\int_0^h f(y) dy} \tag{2}$$

But the quantity

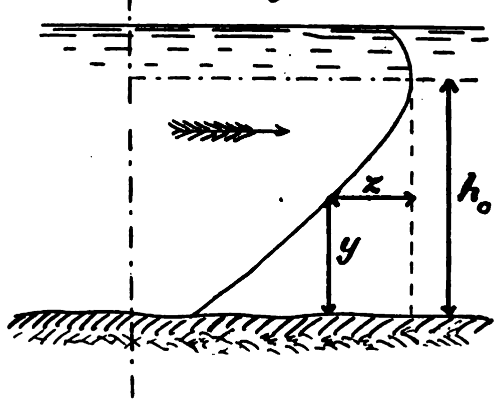
$$\frac{\int_0^h f(y)\, y\, dy}{\int_0^h f(y)\, dy}$$

represents nothing else but the distance Y, of the centre of gravity of the displacement δQ from the surface of the wave; consequently, the velocity of propagation of waves in liquids is expressed by the general formula

$$v = \sqrt{2 g Y} \tag{3}$$

In the case of sea waves raised by the action of the wind, the disturbance begins at the surface and is transmitted to

Fig. 3.



the lower particles of the liquid mass by cohesion. The law of this transmission can be fortunately deduced from the effect the resistance of river beds produce upon the velocity of streams. In fact, we know that, were it not for such resistance, the velocity of streams would be equal in all parts of the cross-section; and that the effect of such resistance is to make the velocity vary from the bottom to the surface according to a law well represented by a parabola whose axis is horizontal and somewhat below the surface, as shown in *Fig. 3.* Thus we know that the dis-

turbance of the particles at the bottom of the stream is transmitted to the other particles according to the law

$$z = \frac{(h_0 - y)^2}{p}$$

in which h_0 is the depth below the vertex of the parabola, and p the parameter of such parabola. This same law holds good also when the disturbance begins at the surface, since the cohesion of the liquid particles is independent of pressure; hence denoting, in this case, by h_0 the depth of the liquid where the horizontal displacement z ceases, we have

$$y = \frac{\int_0^{h_0} (h_0 - y)^2 \, y \, dy}{\int_0^{h_0} (h_0 - y)^2 \, dy} = \tfrac{1}{4} h_0$$

or

$$y = \tfrac{1}{4} \sqrt{p \, z_0}$$

where z_0 is the displacement of a liquid particle at the surface. Observing that $p \, z_0$ must be proportional to the force of the wind, and that the measure of such force can be seen in the amount of liquid raised above the surface, we can assume $p \, z_0$ proportional to $\lambda \, R$, in which λ is the length, and R the height of the wave. Then we can write

$$v = c \sqrt[4]{\lambda \, R} \qquad (4)$$

in which the coëfficient c is to be determined by observation.

According to the observations taken by Dr. Scoresby, in 1848, on the Atlantic Ocean, waves averaging 26 feet in height and 560 feet in length, have a velocity of propagation of about 48 feet per second. With these data, equation (4) gives $c = 4{\cdot}37$, approximately.

Again, according to other observations taken by independent observers, it is found that waves averaging 15 feet in height and 300 feet in length, have a velocity of propaga-

tion of about 36 feet per second. With these data, equation (4) gives $c = 4{\cdot}39$, approximately.

The closeness of these two values of c is certainly remarkable, considering the diversity of the data presented in the two sets of observations reported above. We can, therefore, write with confidence

$$v = 4{\cdot}38 \sqrt[4]{\lambda R} \tag{5}$$

In the case of the tide wave raised by the action of the luni-solar disturbing force upon the waters of the oceans, we know that the horizontal component of such force at any given place is constant at all depths, and therefore the displacement z is also constant. Consequently, we have $Y = \frac{1}{2} h$, in which h is the whole depth of the ocean; and substituting in equation (3), we find

$$v = \sqrt{g h} \tag{6}$$

In tidal rivers, if we denote by u_0, u_1 and u_2, respectively the mean, the surface and the bottom velocities at any given instant in any cross-section whose depth at that instant is h, we find, assuming the parabolic law of velocities in the same vertical,

$$Y = \tfrac{1}{4} h \frac{u_1 + u_2}{u_0}$$

and consequently

$$v = \sqrt{g.h \frac{u_1 + u_2}{2\, u_0}} \tag{7}$$

We may for simplicity put

$$\frac{u_1 + u_2}{2\, u_0} = \mu \tag{8}$$

and write

$$v = \sqrt{\mu g h} \tag{9}$$

There is another reduction to be applied to this formula when the depth h is variable in the same cross-section. Suppose the depth at a distance x, from one end of the cross-section, be represented by

$$y = f(x)$$

then, in order to compute the mean velocity of propagation

of the wave through such cross-section, we have to use the formula

$$v = \frac{\sqrt{g}}{b} \int_0^b \left[f(x) \right]^{\frac{1}{2}} dx$$

in which b represents the width of the cross-section from one end to the other.

Observing that the mean depth of the cross-section is expressed by

$$H = \frac{1}{b} \int_0^b f(x)\, dx$$

we can write

$$v = \frac{\int_0^b \left[f(x) \right]^{\frac{1}{2}} dx}{\sqrt{b} \left[\int_0^b f(x)\, dx \right]^2} \sqrt{g H}$$

If we put

$$y = f(x) = p\, x^n$$

we find

$$\frac{\int_0^b \left[f(x) \right]^{\frac{1}{2}} dx}{\sqrt{b} \left[\int_0^b f(x)\, dx \right]^{\frac{1}{2}}} = \frac{2 \sqrt{n+1}}{n+2}$$

and consequently, equation (9) becomes

$$v = \frac{2}{n+2} \sqrt{\mu (n+1) g H} \qquad (10)$$

Denoting by (H_1) and (H_2), the mean depths of high water and low water in a given length l of a tidal river, then the mean velocities of the crest and the trough of the tidal wave in such distance will be expressed, respectively, by

$$v_1 = \frac{2}{n+2} \sqrt{\mu g (n+1)(H_1)} \qquad (11)$$

and

$$v_2 = \frac{2}{n+2} \sqrt{\mu g (n+1)(H_2)} \qquad (12)$$

The value of μ in these expressions is not necessarily the same. Suppose, for instance, that the river basin enlarges considerably at a certain point, so as to become a kind of reservoir to the river below. If the enlargement were very great, we know that the level of water there would not be affected by tide and would stand at the same elevation as the mean level of the ocean. The effect, therefore, of any enlargement of basin in a tidal river is to more or less reduce the range of tide, and to more or less elevate the plane of low water where the enlargement occurs over the plane of low water of the river below. Hence, while the trough of the tidal wave is advancing in this portion of the river, a more or less strong current, due to the higher elevation of the plane of low water in the enlarged basin, will meet the advancing wave, and finds its escape below the surface, or rather near the bottom, where it adds strength to the bottom velocity u_2 of the ebb. Consequently the value of μ in such case, in equation (12), may be considerably larger than the value of μ in equation (11), since there is no reason for an enlargement of basin to affect the bottom velocity u_2 during high water in any cross-section of the river.

The bottom velocity u_2 during low water is certainly increased when the river discharges a considerable volume of fresh water through the cross-section, for this discharge also finds an easy escape near the bottom, on account of the advancing wave. In both cases, the tendency is, therefore, to increase the value of μ in equation (12); and if we assume that in such cases the bottom velocity does not differ much from the surface velocity, we may consider $\mu = 1$, in such equation.

In ordinary cases, the bottom velocity may be considered small compared with the surface velocity, and then we find according to equation (8), $\mu = \frac{2}{3}$.

As to the value of n, it is safe to assume that the cross-section approaches the parabolic form, when $n = \frac{1}{2}$. Then, taking $g = 32 \cdot 17$, we find in ordinary cases

$$v_1 = 4 \cdot 81 \sqrt{(H_1)} \qquad (13)$$

$$v_2 = 4 \cdot 81 \sqrt{(H_2)} \qquad (14)$$

and for the cases, where the volume of fresh water discharged by the river is considerable with respect to the tidal volume, or where a considerable enlargement of basin occurs, as mentioned above, we may put (assuming $\mu = 1$),

$$\overset{1}{\underset{2}{v}} = 5{\cdot}56 \sqrt{(H_2)} \qquad (15)$$

Denoting by θ_1 and θ_2 the delays in minutes of high water and low water in the distance l computed in statute miles, we find, in ordinary cases, the following formula:

$$\theta_1 = \frac{18{\cdot}3\ l}{\sqrt{(H_1)}} \qquad (16)$$

$$\theta_2 = \frac{18{\cdot}3\ l}{\sqrt{(H_2)}} \qquad (17)$$

and, when the velocity of propagation of the trough is computed according to formula (15), we find

$$\overset{1}{\underset{2}{\theta}} = \frac{15{\cdot}8\ l}{\sqrt{(H_2)}} \qquad (18)$$

Whenever we find that the delay of low water in a given portion of a tidal river corresponds with this formula, we have an evidence that, during low water, the bottom velocity of the ebb is greater than it otherwise would be under ordinary conditions; and this increment of bottom velocity must be due either to a considerable volume of fresh water passing through the various cross-sections of the considered portion of river, or to a considerable enlargement of tidal basin above such portion of river. (These facts may be turned to some advantage in the improvement of tidal rivers.)

In order to test the accuracy of the formulæ (16) and (17), we have selected the portion of the Delaware River between Edgemoor and Fort Mifflin, in which the delays of high water and low water from nearly 400 observations are found to be 73 minutes and 81 minutes, respectively. The distance between the stations is $l = 18{\cdot}7$ statute miles, and from numerous soundings and careful reductions made by the U. S. Coast and Geodetic Survey (*Rep.* 1887), is found

$(H_1) = 20{\cdot}5$ feet, $(H_2) = 18{\cdot}3$ feet. With these data, our formulæ furnish

$$\theta_1 = 75{\cdot}5 \text{ minutes},$$

$$\theta_2 = 80{\cdot}0 \text{ minutes},$$

results which are certainly very satisfactory.

If we take the portion of the upper Delaware above Philadelphia, from Bridesburg up to Burlington, we have a case where the volume of fresh water discharged by the river is considerable when compared to the tidal volume, and consequently for the delay of low water we may use the formula (18). Now the distance between the stations is $l = 12{\cdot}5$ statute miles; and according to a recent determination made by the United States Engineers, the delays of high water and low water are 59 minutes and 55 minutes, respectively, and $(H_1) = 14{\cdot}2$ feet, $(H_2) = 13{\cdot}7$ feet. With these data, we find

$$\theta_1 = 60{\cdot}7 \text{ minutes},$$

$$\overset{1}{\underset{2}{\theta}} = 53{\cdot}5 \text{ minutes},$$

also very satisfactory results.

Again, the portion of the Hudson River, from Governor's Island to Dobbs' Ferry is found below an enlargement of basin which is called Tappan Sea, and, therefore, the delay of low water must also be computed according to formula (18).

The distance between the stations is $l = 24$ statute miles and the Tide-Tables give for the delays of high water and low water 72 minutes and 60 minutes, respectively. According to a publication by the U. S. Coast and Geodetic Survey, we find $(H_1) = 38{\cdot}7$ feet, $(H_2) = 34{\cdot}1$ feet. With these data we get

$$\theta_1 = 70{\cdot}6 \text{ minutes},$$

$$\overset{1}{\underset{2}{\theta}} = 65{\cdot}0 \text{ minutes},$$

which results, though not so satisfactory as before, are not at all improbable. In fact, so far as the delay of high

water is concerned the agreement between the observed and computed values is certainly very good; and the difference of five minutes which appears between the computed and the observed delay of low water only shows that the value of μ, in the present case, is somewhat larger than *one.*

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE

[*Stated Meeting, held at the Institute, Tuesday, November 18, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, November 18, 1890.

Mr. T. C. Palmer, President, in the Chair.

Members present: Dr. L. B. Hall, Dr. H. W. Jayne, Mr. H. Pemberton, Jr., Mr. C. J. Semper, Dr. S. C. Hooker, Dr. Wm. H. Greene, Prof. E. F. Smith, Mr. Reuben Haines, Mr. W. W. Macfarlane, Mr. A. A. Moore, Dr. Wm. H. Wahl, Mr. Philip S. Clarkson, and a number of visitors.

The election of Mr. Cabell Whitehead, of the Mint Bureau at Washington, as an associate member of the Section, was announced.

Mr. Pemberton nominated Mr. Richard D. Baker, 216 South Third Street, Philadelphia, as a member of the Section. The nomination was referred to the Committee on Admissions.

A letter from Mr. Heyl, the Actuary of the Institute, was read, in which certain recommendations were made relative to the course to be pursued in paying bills for journals, etc., the contracting of which had already been formally sanctioned by the Section. The views expressed met with the approval of the Section and the Secretary was directed to so inform the Actuary.

On motion of Mr. Pemberton, it was voted that the Secretary of the Institute be authorized to renew the subscriptions to the journals taken by the Section.

Prof. Smith moved that the Section subscribe for the Bulletin of the French Chemical Society; the motion was carried.

At the suggestion of the treasurer it was voted that he be authorized to purchase 1,000 envelopes for the use of the Section.

On motion of Mr. Pemberton, it was voted that the Section suggest to the Library Committee of the Institute the propriety of completing the sets of all the journals taken by the Section.

The report of the Committee on the Publication of the Paper by Dr. Masser, of Los Angeles, Cal., on "The Curve of the Elements," and also another by Dr. Hans von Strombeck, of New York, on "The Constants of Ammonia," was accepted and the committee was discharged.

On motion of Dr. Wahl, it was voted that a committee be appointed to prepare a circular-letter addressed to chemists at large, setting forth the facilities possessed by the Section to receive, examine and publish promptly papers of meritorious character on chemical subjects.

In this circular-letter, he proposed also to call attention to the fact that a number of printed copies of an accepted paper would be returned to the author, within two weeks of the date of its acceptance by the Section; and furthermore to the fact that the publications of the Section are forwarded promptly, as advance sheets, to the leading chemical journals at home and abroad.

The following nominations of officers for the ensuing year were then made: For President, Dr. Wm. H. Wahl; for Vice-Presidents, Mr. H. Pemberton, Jr., and Dr. Wm. H. Greene; for Secretary and Treasurer, the present incumbents in each case; for Conservator, Dr. Wahl.

Dr. Greene then presented a paper by himself and Dr. Wahl, on "Alloys of Sodium and Lead." It was referred for publication in the Journal.

Dr. Greene also stated that he would submit a number of specimens of new alloys proposed by the authors at the next meeting.

Dr. Wahl then read an abstract prepared by Prof. C. F. Himes, of Carlisle, describing a new photographic process without the use of metallic salts, based on the light sensitive properties of primuline. It was referred for publication. In connection with this paper Mr. Macfarlane stated that the active substance of the process, known as "primuline," and the primuline dyes in general, had been abandoned in dyeing, because of the fact that they would stand exposure to direct sunlight for only a short time before fading out.

Dr. Jayne called attention to a chart illustrating clearly the details of the new process for manufacturing nitric acid, invented by Oscar Goodman, and recently described in various journals.

Mr. Palmer exhibited a piece of logwood which was unusual in presenting a bronzy green surface, such as is commonly found only in chipped wood that has been put through the process of curing. This fragment was part of a log six feet in length, taken from a wind-shaken tree through which rain-water had percolated. The rain-water, probably by the action of the ammonia contained in it, had produced a result analogous to that secured by the usual curing process.

Adjourned. WM. C. DAY, *Secretary.*

ON SOME CONSTANTS OF AMMONIA.*

By Dr. Hans von Strombeck.

[*Read at the Stated Meeting of the Chemical Section, October 21, 1890.*]

If we have to calculate the dimensions of a refrigerating machine it is absolutely necessary to know the exact value of the heat of evaporation (latent heat) of the liquid by means of which the cooling effect is produced. Though in these calculations all designers take the heat of evaporation of liquid ammonia to be about 540 English or 300 French thermal units, nevertheless many of them claim the heat of evaporation of ammonia to be in reality about 900 English or 500 French thermal units. The reason for this assertion is that on being determined the first time the heat of evaporation was found to be about 500 French thermal units. But, as afterwards it was proven that the ammonia used in this test contained a good deal of water, H. V. Regnault repeated the tests with ammonia, absolutely free of any moisture, and found the average figure of the heat of evaporation to be 294·2 French thermal units. To prove once more that this latter figure is correct, and also to decide some other questions relating to ammonia, at the suggestion of Mr. Louis Block, Chief Engineer of the De La Vergne Refrigerating Machine Company, I determined by a series of tests:

(1) The specific heat of liquid ammonia;

(2) The total heat, heat of evaporation and heat of liquid of ammonia;

(3) The heat of absorption of ammonia;

(4) The heat of combination of liquid ammonia and water.

To this is added:

(5) A table showing the difference in the figures for the total heat of evaporation and the heat of absorption.

* From the laboratory of the De La Vergne Refrigerating Machine Co.

I.—DETERMINATION OF THE SPECIFIC HEAT OF LIQUID AMMONIA.

The determination was made in the usual way: The steel cylinder (μ_2) containing the liquid ammonia (M) was suspended in a jacketed drum and heated up to a certain temperature ($T + \delta_1$) by means of the vapor of boiling methylic alcohol which circulated in the jacket. After the liquid ammonia was heated up to a constant temperature, which took about six hours, the steel cylinder (μ_2) with its contents (M) was quickly put in the brass calorimeter (μ) which was filled with a certain quantity of distilled water (m) of a certain temperature (t). By the heat given to m and μ by M and μ_2, the temperature of the water rose from t degrees to $\tau + \delta$ degrees. From the figures thus obtained the specific heat of the liquid ammonia can be calculated.

In the following, all temperatures are in degrees Celsius, all weights in grammes, all measures in cubic centimetres, all thermal units are French ones. The liquid ammonia used in all the following tests was manufactured in the gas plant of the De La Vergne Refrigerating Machine Company. Its composition was:

99·926 per cent. ammonia;
0·055 per cent. mineral oil (liquid base) which originates from a patented process used in the manufacture of the liquid ammonia;
0·019 per cent. moisture.

If, in the following:

M = the weight of the gaseous and liquid ammonia and its contaminations in the steel cylinders;

$M - \mu_3 - \mu_4 - \mu_6$ = the weight of the liquid ammonia;

m = the weight of the water in the calorimeter;

μ = the weight of the brass calorimeter and the metal part of the agitator;

σ = its specific heat;

$\mu\,\sigma$ = its value in water;

$\mu_1\,\sigma_1$ = the value in water of the thermometer in the calorimeter;

μ_2 = the weight of the steel cylinder;
σ_2 = its specific heat;
$\mu_2 \sigma_2$ = its value in water;
v = the contents of the steel cylinder in cubic centimetres;
$\epsilon (T + \delta_1)$ = the specific gravity of liquid ammonia at $T + \delta^1$ degrees;
$\phi (T + \delta_1)$ = the pressure in atmospheres exerted by gaseous ammonia at $T + \delta^1$ degrees;
μ_3 = the weight of the gaseous ammonia above the liquid at $T + \delta^1$ degrees and corresponding pressure;
σ_3 = its specific heat at constant volume;
$\mu_3 \sigma_3$ = its value in water;
μ_4 = the weight of the mineral oil contained in $M - \mu_3$ grammes of liquid ammonia;
σ_4 = its specific heat;
$\mu_4 \sigma_4$ = its value in water;
μ_6 = the weight of the moisture contained in $M - \mu_3$ grammes of liquid ammonia;
$\epsilon (\tau + \delta)$ = the specific heat of liquid ammonia at $\tau + \delta$ degrees;
$\phi (\tau + \delta)$ = the pressure in atmospheres exerted by gaseous ammonia at $\tau + \delta$ degrees;
μ_5 = the weight of the gaseous ammonia above the liquid at $\tau + \delta$ degrees and corresponding pressure;
$\mu_3 - \mu_5$ = the weight of the gaseous ammonia, which became a liquid when the temperature went down from $T + \delta_1$ to $\tau + \delta$ degrees;
r = the heat of evaporation of. liquid ammonia in thermal units;
$(\mu_3 - \mu_5) r$ = thermal units developed by the liquefaction of $\mu_3 - \mu_5$ grammes of gaseous ammonia;

$t =$ the temperature indicated by the thermometer in the water of the calorimeter at the beginning of the test;

$\tau =$ the temperature indicated by the thermometer in the water of the calorimeter at the end of the test;

$\delta =$ the fraction of a degree, which is to be added to τ, so as to obtain the temperature;

$\tau + \delta$ which the water in the calorimeter would have had, if no loss of heat had taken place by the cooling influence of air and by radiation;

$\tau + \delta - t =$ the corrected number of degrees by which the water in the calorimeter was heated up;

$T =$ the temperature of the gaseous and liquid ammonia and its contaminations in the steel cylinder and of the cylinder itself, as indicated by the thermometer;

$\delta_1 =$ the fraction of a degree, which is to be added to T, so as to obtain the temperature;

$T + \delta_1$ which the thermometer would have indicated if its mercury column had not projected over the cover of the jacketed drum;

$T + \delta_1 - (\tau + \delta) =$ the decrease of temperature, which the gaseous and liquid ammonia and its contaminations in the steel cylinder and the cylinder itself underwent;

$x =$ the specific heat of liquid ammonia that is to be determined.

We have—

$$x = \frac{(m + \mu\sigma + \mu_1\sigma_1)(\tau + \delta - t) - (\mu_2\sigma_2 + \mu_3\sigma_3 + \mu_4\sigma_4 + \mu_6)(T + \delta_1 - (\tau + \delta)) - (\mu_3 - \mu_5)r}{(M - \mu_3 - \mu_4 - \mu_6)(T + \delta_1 - (\tau + \delta))}$$

AUTHENTICAL PROOFS OF THE DETERMINATION OF THE SPECIFIC HEAT OF LIQUID AMMONIA.

	1.	2.	3.	4.	5.	6.	7.	8.
M,	128·3	128·1	128·1	128·1	128·1	128·0	128·0	128·0
$M - \mu_3 - \mu_4 - \mu_6$,	127·7516	127·5313	127·5276	127·5146	127·5237	127·4266	127·4262	127·4206
m,	980·0							
μ,	216·2							
σ,	0·0939							
$\mu\,\sigma$,	20·30							
$\mu_1\sigma_1$,	6·37							
μ_2	1357·6							
σ_2,	0·117687	These values are the same in all eight tests.						
$\mu_2\,\sigma_2$,	159·77							
v,	262·75							
μ_4,	0·071							
σ_4,	0·4618							
$\mu_4\,\sigma_4$,	0·033							
μ_6,	0·024							
r,	294·2							
$\varepsilon T + \delta_1$,	0·5470	0·5466	0·5471	0·5473	0·5462	0·5469	0·5457	0·5454
$\phi T + \delta_1$,	27·06	27·21	26·98	26·92	27·41	27·13	27·55	27·69
μ_3,	0·4734	0·4737	0·4774	0·4904	0·4813	0·4784	0·4788	0·4844
σ_3,	0·3606	0·3606	0·3606	0·3606	0·3606	0·3606	0·3606	0·3606
$\mu_3\,\sigma_3$,	0·1707	0·1718	0·1721	0·1769	0·1735	0·1795	0·1737	0·1747
$\varepsilon\,\tau + \delta$,	0·5895	0·5929	0·5926	0·5907	0.5965	0.5892	0.5886	0.5893
$\phi\,\tau + \delta$,	12·15	11·27	11·35	11·79	11·24	12·23	12·45	12·19
μ_5,	0·3317	0·3636	0·3624	0·3704	0·3854	0·3784	0·3833	0·3788
$\mu_3 - \mu_5$,	0·1417	0·1101	0·1150	0·1200	0·0959	0·1000	0·0955	0·1056
$(\mu_3 - \mu_5)\,r$,	41·68	32·66	33·83	35·30	28·21	29·42	28·10	31·06
t,	21·50°	18·25	18·64	20·40	18·00	21·83	22·20	21·39
τ,	31·15	28·71	28·93	30·28	28·67	31·42	32·00	31·38
δ,	0·139	0·092	0·09	0·114	0·054	0·119	0·073	0·095
$\tau + \delta$,	31·289	28·802	29·02	30·394	28·724	31·539	32·073	31·475
$\tau + \delta - t$,	9·789	10·552	10·38	9·994	10·724	9·709	9·873	10·085
T,	62·17	62·45	62·05	61·97	62.70	62·26	63·02	63·14
δ_1,	0·075	0·077	0·075	0·069	0·073	0·078	0·07	0·073
$T + \delta_1$,	62·245	62·527	62·125	62·039	62·773	62·338	63·09	63·213
$T + \delta_1 - (\tau + \delta)$,	30·956	33·725	33·105	31·645	34·049	30·799	30·017	31·738
x,	1·22888	1·20757	1·21242	1·22941	1·22563	1·22720	1·25191	1·24707

Average of x, ... 1·22876

As this result was somewhat surprising, I wanted to make absolutely sure that no mistake had taken place in these tests; I therefore filled distilled water into the steel cylinder μ_2 and determined its specific heat. As I expected, I got a value close to one, namely 0·99302.

The values of μ_3 and μ_5 were calculated in the following manner; I take the figures obtained in the sixth test for example:

(1) μ_3: $T + \delta_1 = 62{\cdot}338^\circ$ $\varepsilon T + \delta_1 = 0{\cdot}5469$ $\phi T + \delta_1 = 27{\cdot}13$ atm.

$M = 128{\cdot}0$ grs. $v = 262{\cdot}75^{cm}$ 1^{cm} of gaseous ammonia weighs at 0° and 760^{mm} pressure 0·0007614 grammes. Consequently, if the steel cylinder were entirely filled with liquid ammonia, its contents would weigh $262{\cdot}75 \times 0{\cdot}5469 = 143{\cdot}68$ grs. As they weigh only 128·0 grs., we have the following equation: $262{\cdot}75^{cm} : 143{\cdot}68 \text{ grs.} = x^{cm} : 128{\cdot}0 \text{ grs.}$ $x = 234{\cdot}04^{cm}$ were filled with liquid ammonia. The rest $262{\cdot}75 - 234{\cdot}04 = 28{\cdot}71^{cm}$ were filled with gaseous ammonia, which under the prevailing circumstances weigh

$$\frac{28{\cdot}71 \times 0{\cdot}0007614 \times 27{\cdot}13 \times 273}{273 + 62{\cdot}338} = 0{\cdot}4784 \text{ grs.}$$

(2) μ_5 : $\tau + \delta = 31{\cdot}539^\circ$ $\varepsilon\tau + \delta = 0{\cdot}5892$ $\phi\tau + \delta = 12{\cdot}23$ atm. Doing the same calculations as above we obtain $x = 217{\cdot}43^{cm}$, or $45{\cdot}32^{cm}$ were filled with gaseous ammonia, which weigh 0·3784 grs.

II.—DETERMINATION OF THE TOTAL HEAT—HEAT OF EVAPORATION AND HEAT OF LIQUID OF AMMONIA.

In making this test I generally followed the course taken by H. V. Regnault (cf. *Ann. d. chim.*, xxiv, p. 375, pf.), but made the following two modifications:

(1) I introduced the value 1.22876 determined sub. I) for the specific heat of ammonia which Regnault supposed to be 0·799.

(2) I determined the value y_1 (cf. p. 476, pf.) which is necessary to be known for the calculation of the total heat and heat of liquid.

The test was made in the following way: The apparatus consists of two calorimeters *ABCD* and *EFGH*, which are

filled in each test with 4,300 and 600 grs. of water respectively. Three tanks securely connected with each other by the brass-block *abcd* are put in the first calorimeter. Tank *IKL* is filled with the liquid ammonia *P*. During the test the ammonia gas escapes through the cock *Z* (the construction of which allows the regulation of the escape of the ammonia in the minutest manner) and the tanks *MNO* and *PQR* into

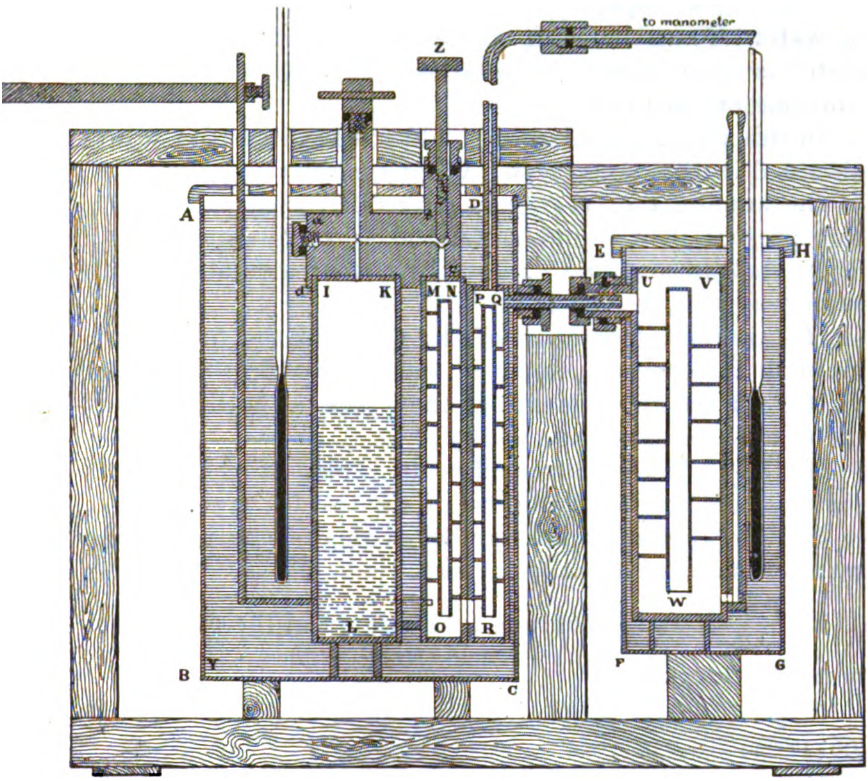


FIG. 1. Apparatus for the Determination of the Latent Heat of Ammonia.

tank *UVW*, put in the second calorimeter, and from it into the atmosphere. Small semi-circular plates are spirally fixed in these tanks so as to cause the gas to entirely equalize its temperature with that of the surrounding water. A small mercury manometer connected with *PQR* allows the control of the pressure of the escaping gas at any moment. By means of the agitator *y*, the temperature of the water is

kept the same in all strata. To lessen the influence of the air and to prevent the calorimeters as much as possible from radiating, the calorimeters are covered with wooden covers and the whole apparatus put in a wooden box.

The first calorimeter with its three tanks weighs 3,800 grs.; the second one 1,579 grs. The specific heat of their material (brass) being 0·0939 their values in water are 356·8 and 148·3 grs. respectively. Consequently the total weight of water (M) which is to be heated up in the first calorimeter is 4656·8 grs.; the total weight (M_1) in the second calorimeter 748·3 grs.

In this paper I shall always add to each item the figures obtained in the sixth test. What quantity P_1 (114·63 grs.) of the ammonia P (114·95) in tank IKL (capacity 242·05^{ccm}) was present in a liquid state, and what quantity $P - P_1$ (0·32) was present in a gaseous one, was calculated in the same way as μ_3 in I, p. 472.

If T is the temperature of the water in the first calorimeter at the commencement of the test (20°·69);

If T_1 is the temperature of the water in the first calorimeter at the end of the test (13°·82);

If $T_1 + \delta$ is the corrected temperature of the water in the first calorimeter at the end of the test (13°·5725);

If $T - (T_1 + \delta)$ is the number of degrees by which the water was cooled down (7°·1175);

If $\frac{T + T_1}{2}$ is the average temperature in the first calorimeter (17°·255);

If $\phi\, T$ is the tension of the ammonia vapor at $T°$ (6643$^{mm.}$);

If $\phi\, T_1$ is the tension of the ammonia vapor at $T_1°$ (5252$^{mm.}$);

If $\phi\, \frac{T + T_1}{2}$ is the average of both tensions (5947$^{mm.}$);

If τ is the temperature of the water in the second calorimeter at the commencement of the test (19°·11);

If τ_1 is the temperature of the water in the second calorimeter at the end of the test (18°·83);

If $\tau_1 + \delta_1$ is the corrected temperature of the water in the second calorimeter at the end of the test (18°·9816);

If $\tau - (\tau_1 + \delta_1)$ is the number of degrees by which the water was cooled down (0°·1284);

If $\frac{\tau + \tau_1}{2}$ is the average temperature in the second calorimeter (18°·97);

If ε is the mechanical equivalent of heat used under the prevailing circumstances by the gaseous ammonia for its expansion (317·4);

If c is the specific heat of gaseous ammonia (0·5084);

If C is the specific heat of liquid ammonia (1·22876).

The loss of heat, which both calorimeters together undergo, is

$$M[T - (T_1 + \delta)] + M_1[\tau - (\tau_1 + \delta_1)] = -33144{\cdot}8 - 96{\cdot}8$$
$$= -33241{\cdot}6 \text{ thermal units.}$$

But we have to make some corrections. There are to be subtracted:

(α) The quantity of heat s required by $P - P_1$ for changing its temperature from

$$T^\circ \text{ to } \tau^\circ;\ s = (P - P_1)\,c\,(T - \tau) = -0{\cdot}2$$

(β) The quantity of heat q_1 required by $P - P_1$ for ex panding down to the atmosphere:

$$q_1 = \frac{10333\,(P - P_1)\,(273 + T)}{0{\cdot}7614\,.\,\varepsilon\,.\,273} = -9{\cdot}3$$

(γ) The quantity of heat s_1 required by P_1 for changing its temperature from

$$\frac{T + T_1}{2} \text{ to } \frac{\tau + \tau_1}{2}$$

after it had become a gas;

$$s_1 = P_1\,c\left(\frac{\tau + \tau_1}{2} - \frac{T + T_1}{2}\right) = -100{\cdot}0$$

There are to be added:

(δ) The quantity of heat s_2, which would have been

required by P_1, if it had been filled into the tank *IKL* at

$$\frac{T+T_1}{2}\ ;\quad s_2 = P_1\, C\left(T - \frac{T+T_1}{2}\right) = -387{\cdot}6$$

(ϵ) The quantity of heat q_2 required by P_1, in order to cool itself down to the temperature T_0, at which in reality it evaporates in tank *IKL*.

From the commencement of the evaporation, as soon as the gas begins to expand, the pressure prevailing in *IKL* ceases, being the one which corresponds to

$$\frac{T+T_1}{2} \text{ degrees,}$$

but it is lower. But if the pressure become lower, the temperature of evaporation must correspondingly become also lower, temperature and pressure of saturated vapor being dependent upon one another. Regnault, in determining the heat of evaporation of liquid carbonic acid, determined the decrease of temperature (y_1), which must be given to carbonic acid, in order to produce a cooling effect equal to the one produced, if it expands from a pressure of 1,000^{mm} above the atmosphere down to the atmosphere. This value y_1, not being known for ammonia, I determined it, entirely following the way used by Regnault, in determining y_1 for carbonic acid.

We first determine the decrease of temperature (y), which must be given to the unit of gaseous ammonia, in order to produce a cooling effect equal to the one produced if it expands from a pressure above the atmosphere ϕ down to the atmosphere, and from the so obtained value y we calculate the value y_1 for a pressure of 1,000^{mm} above the atmosphere.

Ammonia gas is developed in tank *A* (*Fig.* 2) and passes through the coils *FG* lying in the large tank *BCDE*, filled with water. At *a* the pipe enters the calorimeter *IKLM*. At *n*, the pipe of an inside diameter of 5^{mm} suddenly changes to a capillary tube, which at *o* changes again to a pipe of 5^{mm} diameter. An agitator in each tank keeps the temperature of the water equalized in all strata.

The ammonia, on entering the capillary tube at *n*, has the pressure corresponding to the temperature of the water in the large tank. On entering the wider tube at *o* and while passing through it, it expands down to the atmosphere. We admit that while passing through both tubes, the ammonia gas has the same temperature as the water in the calorimeter.

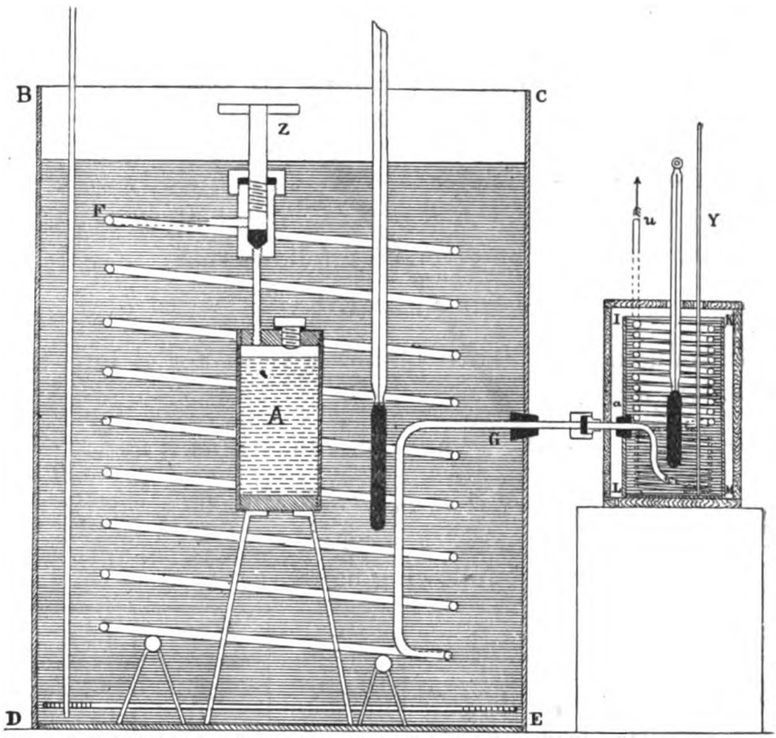


FIG. 2. Apparatus for the Determination of y_1.

If $M =$ the total quantity of water which is to be heated up, consisting in each test of 767 or 768 grs. of water and 104 grs. value in water of the tank;

$\phi =$ the pressure above the atmosphere expressed in mm. of mercury, at which the evaporation of ammonia takes place;

$\pi =$ the weight of the ammonia;

$\vartheta =$ the average temperature of the ammonia on entering the calorimeter;

ϑ_1 = the average temperature of the water in the calorimeter;

θ = the change of temperature which the water in the calorimeter underwent;

ω = the loss of heat caused by the ammonia by changing its pressure from ϕ to the atmosphere H;

c = the specific heat of gaseous ammonia = 0·5084.

We have:

The gaseous ammonia π entering the calorimeter at ϑ and leaving the same at ϑ_1, for doing so uses a quantity of heat $\pi c (\vartheta - \vartheta_1)$, its value being positive or negative, according to the value of $\vartheta >$ or $< \vartheta_1$. The quantity of heat taken from the calorimeter is $M \theta$. Consequently we have:

$$\omega + \pi c (\vartheta - \vartheta_1) = M \theta \text{ or } \omega = M \theta - \pi c (\vartheta - \vartheta_1).$$

From the definition given of y follows that

$$\omega = \pi c y \text{ or } y = \frac{\omega}{\pi c}$$

Introducing the above obtained value for ω into this equation, we have:

$$y = \frac{M \theta - \pi c (\vartheta - \vartheta_1)}{\pi c} \text{ and consequently as } y_1 = \frac{y \cdot 1000}{\phi}$$

$$y_1 = \frac{[M \theta - \pi c (\vartheta - \vartheta_1)]\, 1000}{\pi c \phi}$$

The tests gave the following figures:

	1.	2.	3.	4.
ϕ,	5274·4 mm.	5259·2	5285·8	5441·6
π,	367·8 grs.	387·1	163·0	169·1
M,	871·0 grs.	871·0	872·0	872·0
ϑ,	18·563°	18·496	18·585	19·485
ϑ_1,	17·654°	14·996	19·325	18·871
$\vartheta - \vartheta_1$,	0·909°	3·500	— 0·840	0·614
θ,	— 1·538°	— 0·9887	— 0·7403	— 0·7303
$M \theta$,	— 1339·6 c.	— 861·2	— 645·3	— 636·6
$\pi c (\vartheta - \vartheta_1)$,	170·0 c.	688·8	— 69·6	52·7
ω,	— 1509·6 c.	— 1550·0	— 575·7	— 689·3
y,	— 8·07°	— 7·86	— 6·95	— 8·02
y_1,	— 1·530°	— 1·494	— 1·315	— 1·473

Taking the average, we obtain $y_1 = - 1°\cdot453$.

We return now to p. 476ε. Even now we are not able to determine the temperature T_0 directly, but we can determine the pressure (f) at which the ammonia in tank *IKL* evaporated and from it figure the corresponding temperature T_0.

The gas P, as well that developed by the liquid P_1 as the gaseous one $P - P_1$, expands from the unknown pressure f to the atmosphere H, for which it requires a quantity of heat q_0 expressed, according to the above said, by

$$\text{equation (1) } q_0 = P c y_1 \frac{f - H^2}{1000}$$

The gas P, by its passing through the second calorimeter under the pressure H, takes $M_1 (\tau - (\tau_1 + \delta_1))$ thermal units from it, during the same time changing its temperature from

$$\frac{T + T_1}{2} \text{ to } \frac{\tau + \tau_1}{2}$$

for which purpose

$$P c \left(\frac{T + T_1}{2} - \frac{\tau - \tau_1}{2}\right)$$

thermal units are required. If the gas P, on its entering the second calorimeter, had had the temperature

$$\frac{\tau + \tau_1}{2}$$

which it has on leaving the same, the heat required q_0 would be expressed by

$$\text{equation (2) } q_0 = M_1 [\tau - (\tau + \delta_1)] + P_c \left(\frac{T + T_1}{2} - \frac{\tau + \tau_1}{2}\right)$$

Now, if the calculated average pressure

$$\phi \frac{T + T_1}{2}$$

be the real prevailing one,

$$\phi \frac{T + T_1}{2}$$

must be equal to f. Thus by putting the value obtained for

$$\phi \frac{T + T_1}{2}$$

in equation (1) for f and by figuring up both equations for q_0, we must, of course, obtain the same value for q_0 if our supposition

$$\phi \frac{T + T_1}{2}$$

to be equal to f be correct. Again, taking the figures obtained from the sixth test, we have

From equation (1) $q_0 = -433{\cdot}3$

From equation (2) $q_0 = -191{\cdot}4$

whence follows that f is not equal

$$\phi \frac{T + T_1}{2}$$

but smaller. If we introduce the value obtained from equation (2) for q_0 into equation (1) and figure it up for f we have

$$f = \frac{1000 \,.\, q_0}{y_1 \, P \,.\, c} + H = 3018^{\text{mm}}$$

This was the real prevailing pressure at which the liquid in tank *IKL* evaporated.

The boiling point T_0, corresponding to this pressure, is $-0^\circ{\cdot}06$. Consequently we have—

$$q_2 = P\,C\left(\frac{T + T_1}{2} - T_0\right) = -2446{\cdot}1$$

Thus, the total heat (Q) required by the quantity of ammonia (P), at a certain temperature

$$\frac{T + T_1}{2}$$

is

$$Q = M[T - (T_1 + \delta)] + M_1[\tau - (\tau_1 + \delta_1)] - s - q$$
$$- s_1 + s_2 + q_2 = -35965{\cdot}8$$

or

The total heat (λ) required by the unit is

$$\frac{Q}{P} = -313{\cdot}7 \text{ thermal units.}$$

p AMMONIA.

		6.	AVERAGE.
P,		114·95	
$P - P_1$,		0·32	
P_1,		114·63	
M,		4656·8	
$\phi\, T$,		6643	
$\phi\, T_1$,		5252	
$\phi\, \frac{T + T_1}{2}$		5947	5863 mm. or 7·71 atm. abs. press.
f,		3018	2987 mm. or 3·93 atm. abs. press.
T_0,		$-$0·06	$-$0·86° C. or 30°·45 F.
T,		20·69	
T_1,		13·82	
$T_1 + \delta$,		13·5725	
$T - (T_1 + \delta)$,		$-$7·1175	
$\frac{T + T_1}{2}$		17·255	17°·00 C. or 62°·60 F.
$M\,[T - (T_1 + \delta)]$,		$-$33144·8	
ε,		317·4	
c,	4	0·5084	
C,	76	1·22876	
M_1,		748·3	
τ,		19·11	
τ_1,		18·83	
$\tau_1 + \delta_1$,	78	18·9816	
$\tau - (\tau_1 + \delta_1)$,	82	$-$0·1284	
$M_1\,(\tau - [\tau_1 + \delta_1])$,		$-$96·8	
$M_1\,[\tau - (\tau_1 + \delta)] + \lambda$		$-$191·7	
$M\,[T - (T_1 + \delta)] + \lambda$		$-$33241·6	
s,		$-$0·2	
q_1,		$-$9·3	
s_1,		$-$100·0	
*s_2,		$-$387·6	
y_1,		$-$1·453	
q_2,		$-$2446·1	
Q,		$-$35965·8	
$\lambda = Q/P$,		$-$313·7	$-$318·8 French or $-$573·8 English cal.
$q = q_2/P_1$,		$-$21·3	$-$22·0 " $-$39·6
$r = \frac{Q - q_2}{P_1}$		$-$292·4	$-$296·8 " $-$534·2

The heat of liquid (q) of the unit is

$$\frac{q_2}{p} = -\ 21{\cdot}3 \text{ thermal units.}$$

The heat of evaporation (r) of the unit is

$$\frac{Q - q_2}{p} = -\ 292{\cdot}4 \text{ thermal units.}$$

In the accompanying table, I give the figures obtained in the tests.

[*To be continued.*]

THE ACTION OF HYDROGEN SULPHIDE GAS UPON METALLIC AMINES.

BY EDGAR F. SMITH AND HARRY F. KELLER.

[*Read at the Stated Meeting of the Section, held October 21, 1890.*]

When pure, dry hydrogen sulphide gas was conducted over palladammonium chloride, Pd $(NH_3Cl)_2$, no change occurred in the appearance of the compound. However, on applying a gentle heat (70°–80° C.) to the boat containing the metallic amine, the latter gradually assumed a black color. This change extended throughout the entire mass. Upon increasing the heat ammonium chloride was volatilized. The residue was found to consist of palladium and sulphur. Single mineral acids were without effect upon it. Aqua-regia attacked it very slowly.

(I) — 0·3790 gram of Pd $(NH_3Cl)_2$ gave 0·2498 gram of the black sulphide. Assuming that the latter is represented by the formula PdS, the required monosulphide for the quantity of palladammonium chloride used would be 0·2484 gram.

(II) 0·2795 gram Pd $(NH_3Cl)_2$ gave 0·1822 gram sulphide, while the calculated amount should be 0·1831 gram.

This behavior of the palladammonium chloride led us to expose the following metallic amines to the action of hydrogen sulphide gas:

PURPUREO-COBALTIC CHLORIDE (Co_2Cl_6, $10NH_3$).—0·5287

gram of this substance, finely divided, were weighed out in a porcelain boat. The latter was placed in a combustion tube of hard glass. This was in connection, on the one side with a drying apparatus, on the other with a Peligot tube containing water. The latter served to produce a back-pressure of the gas, and in this manner the boat and its contents were constantly surrounded by an atmosphere of hydrogen sulphide. The gas was at first allowed to act in the cold. It produced an immediate change. The cobalt amine assumed an intense black color. To all appearances the change was complete in a few minutes, and extended through the entire salt. On the application of a gentle heat (80°) ammonium chloride volatilized. Later the heat was raised, and a current of carbon dioxide substituted for the hydrogen sulphide. The boat was allowed to cool down in this gas. The final product was dense, and black in color. Its weight was 0·2258 gram. Assuming the change of the amine was to sesquisulphide the amount of the latter, corresponding to 0·5287 gram of the amine, would weigh 0·2253 gram. On examining the sulphide it was found to consist of sulphur and cobalt.

ROSEO-COBALTIC SULPHATE ($Co_2(SO_4)_3, 10NH_3 + 5H_2O$).—This salt, too, sustained an immediate change when acted upon in the cold by hydrogen sulphide. There was in addition a simultaneous evolution of moisture, and stellated, colorless crystals appeared on the walls of the combustion tube. These gradually dissolved in the water present, and imparted to it an intense yellow color. The crystals were $(NH_4)_2S_2$. On gently heating roseo-cobaltic sulphate in a stream of hydrogen sulphide, it invariably happened that when a temperature of 70° C. was attained, the black mass, in the boat, swelled up considerably, and was projected into the tube. Some deep-seated change occurred, which we are not prepared to explain at present.

LUTEO-COBALTIC CHLORIDE ($Co_2Cl_6, 12NH_3$).—This salt was affected by hydrogen sulphide in the cold, although heat was required to bring about a complete change. One quantitative determination gave the same result as was obtained

with purpureo-cobaltic chloride, *i. e.*, the product was evidently cobalt sesquisulphide.

Of the cobalt amines examined, the roseo-derivative was most rapidly changed by the gas. We have good reasons for believing that we can make this reaction serviceable in the determination of cobalt in these bases.

PURPUREO-CHROMIC CHLORIDE ($Cr_2Cl_6,10NH_3$).—We exposed this salt for a long period, in the cold, to the influence of hydrogen sulphide, without its sustaining any alteration. On raising the temperature so that it was slightly lower than the dissociation temperature of hydrogen sulphide, the purple-colored amine became quite black in color. It had a velvety appearance and resembled the chromium sesquisulphide obtained by other methods.

(I) 0·6390 gram substance gave 0·2640 gram sulphide. The theoretical amount should be 0·2629 gram.

When this sulphide is exposed to a high heat in a current of hydrogen gas, it parts very slowly with its sulphur.

It is our intention to apply this reaction to other metallic amines as soon as we can do so, though at present our work has been interrupted by unforeseen circumstances.

UNIVERSITY OF PENNSYLVANIA,
PHILADELPHIA, October 17, 1890.

ALLOYS OF SODIUM AND LEAD.

BY WM. H. GREENE AND WM. H. WAHL.

[*Read at the Meeting of the Chemical Section, November 18, 1890.*]

Recently, in the course of certain investigations, in which we had occasion to make use of alloys of lead and sodium, we found that the properties of such alloys did not correspond with what we had anticipated from previous publications on the subject, and we were led to an examination of the properties of lead-sodium alloys of definite composi-

tion. These alloys may easily be made by direct combination, and the products are then sensibly constant in composition, which is not the case when they are prepared by reducing lead oxide by carbon in presence of soda, or by heating litharge with sodium tartrate, as described by Vanquelin and Serullas.

The required quantity of sodium was added to lead melted in a covered crucible, and the alloy was roughly analyzed by determining lead only. Our alloys contained from three to thirty-one per cent. sodium. They are all brittle and crystalline; all decompose water, that containing the least sodium producing a hardly perceptible evolution of gas, while that containing thirty-one per cent. reacts with violence. The brittleness and oxidability increase with the percentage of sodium. The richest alloy is greenish in color and instantly blackens on exposure to air.

We made special examinations of the alloys corresponding in composition to Na_2Pb_2, Na_2Pb and Na_4Pb: the first of these contained ten per cent. sodium, the second 19·5 per cent, rather more than would be indicated by the formula, while the last contained 31·7 per cent. The densities were determined in aniline and found to be considerably higher than would be the densities of mixtures of the same composition. Thus the ten per cent. alloy has a density of 6·91, the 19·5 per cent. a density of 4·61, and the 31·7 per cent. alloy a density of 3·81. The densities of corresponding mixtures would be 5·6, 3·7 and 2·7, respectively.

The theoretical and calculated percentages of Na in alloys of above assumed composition compare as follows:

	Pb_2Na_2	Pb_2Na	Pb_4Na
P.C.Na by theory,	10	18·18	30·8
" found,	10	19·5	31·7

A NEW PHOTOGRAPHIC PROCESS WITHOUT METALLIC SALTS.

This process was presented at the recent meeting of the British Association for the Advancement of Science, by Mr. A. G. Green, and his co-laborers, Messrs. Cross and Bevan, in a paper detailing highly successful experiments with primuline for producing designs on cotton, linen or silk cloths, on paper, and, by aid of gelatine, on glass, etc., by a "photographic method of dyeing and printing." The process requires no longer time of exposure than that with silver salts, whilst it has a more general range of sensitiveness in the spectrum, and at the same time affords the choice of a great variety of colors for the finished prints; and as primuline is a commercial article used on a large scale, it is comparatively inexpensive. The process will only be outlined in brief. Primuline, a coal-tar product, is an amido-sulphonic acid discovered by Mr. Green, in 1887, and named by reason of the primrose yellow color imparted by it to cotton in alkaline solution, without a mordant. It has been quite extensively used for producing a great variety of colors in cotton cloth by *diazotizing* the compound in the cloth dyed with primuline, by passing it through a weak solution of nitrous acid, or rather of a nitrite with an acid, and thus imparting to it the property of combining with various phenols or amines to produce in the fabric a variety of highly colored, very fast dyes—the so-called ingrain colors, the particular color in any case being determined by the phenol or amine employed in solution rendered acid or alkaline as may be necessary. It was found that the diazotized compound is extremely sensitive to light, which destroys this property of combining with the phenols and amines, so that a fabric dyed with primuline, then washed and treated with nitrite of soda and acetic acid, and again washed, and then exposed, either moist or dry under any design, as a drawing or a negative, will lose

the property of becoming dyed by the phenols and amines in the parts acted upon by light, so that in a subsequent treatment with a suitable amine or phenol, as a developer, only the protected parts will become dyed, and a print will be produced having the positive or negative character of the original. Thus the lines of a drawing will be reproduced in color. By selection of the suitable developer not only one of a great variety of colors may be given, but by applying two developers, mixed with starch paste locally by means of a brush, two colors may be produced in the same fabric. The fixing of the print is accomplished by simply washing it with water. The following developers were given: For *red*, an alkaline solution of beta-naphthol; for *maroon*, of beta-naphthol-disulphonic acid; for *yellow*, of phenol; for orange, of resorcin; for *brown*, a solution of phenylene-diamine hydrochloride; for *purple*, a solution of alpha-naphthylamine hydrochloride. Paper for copying plans, etc., may be coated by means of a brush or roller. The process is in its tentative stage and full of promise in many directions. According to an article in the *British Journal of Photography*, based on further experiments, and giving working formulæ, the dressing should be removed from ordinary muslin for use by this process; the exposure required is less than with ordinary albumenized paper, but negatives of greater density are required; and, what is of highest interest, a simple aqueous solution of either of the common photographic developing agents, eikonogen and pyrogallol, will act as an energetic developer, the former giving the much desired ink-black tone and the latter a brown tone.

C. F. H.

NOTES AND COMMENTS.

MECHANICS.

THE MANNESMANN TUBES.—At the stated meeting of the Institute, for the month of November, 1890, the secretary exhibited a number of specimens of tubes (and of special forms made from the same), rolled by the method invented and developed industrially by the brothers Reinhard and Max Mannesmann, of Remscheid, Germany, and described the process of manufacture and the uses of the products. The following abstract of a paper descriptive of a similar exhibit made by Dr. Hermann Wedding at the International Meeting of Engineers, lately held at Pittsburgh, is reproduced from the *American Manufacturer:*

" * * * The exhibit was most interesting from an engineering point of view, marking, as the invention does, an epoch in the mechanical department of the metallurgy of iron and steel, and being one of the most radical innovations ever made in the methods of mechanically manipulating metal.

"More or less has already been published concerning the process and the appliances used in the production of these tubes, though of the importance which the manufacture has already assumed, the rapidly increasing capacity of the plants engaged in their production, and the great measure of success which has already attended their manufacture and use, comparatively little has heretofore been made public in this country. It is of these last-named features with which this article will have principally to deal. And while to give a description of the method of manufacture may seem superfluous, a brief sketch of the process may not be out of place in this connection.

"The method is of special use in the making of pipes designed to withstand heavy pressures, and must be regarded as an important improvement. It is a departure from previous practice in such manufacture well calculated to work a revolution in the methods of manufacturing, as well as the results obtained, which are most remarkable. The process consists in feeding a solid, heated bar of ingot metal between rolls, which, while their axes are oblique to the axis of revolution, revolve both in the same direction. The metal of the surface of the bar thus acquires an increased motion in a spiral direction, and is drawn over its core, receiving consequently the form of a pipe. Since, in this operation, the pipe moves spirally forward, and all its parts are spirally pushed and pressed the metal becomes still denser. It is this spiral arrangement of the metal which makes the Mannesmann pipes so remarkable, quite apart from the advantage they possess in presenting no lines of welding whatever. Moreover, blowholes (which are invariably present in ingot iron), are so squeezed out spirally as to make the walls of the pipe completely impermeable. A proof of this is the retention of hydrogen for weeks in a piece of Mannesmann pipe, closed at both ends. Pipes thus made and enlarged have been successfully produced of all diameters up to eighteen inches.

"A serious obstacle which had to be overcome by special design of machinery lay in the excessive unit stresses in the teeth of common gearing when transmitting very high powers at high rates of speed. Likewise special coupling for the different parts of the machinery had to be devised for the various parts of the machinery. A special form of fly-wheel for the steam engines used was devised, being built up of steel discs with a rim of wire under high initial tension, cast-iron wheels being entirely unsuitable for the high speeds at which it is necessary to run the engine. The details of construction of much of this special machinery has been kept a secret with the manufacturers.

"In addition to the rolls in making the tubes, a mandrel may be used, improving the product, in that the pipe is at once made smooth and more nearly perfect inside than would be the case otherwise.

"The proportion of the inside diameter or bore of the tube may be varied within wide limits. In work thus far done, it has been possible to make a tube, say of one and one-half inches outside diameter, with a bore not larger than a small wire, say one-sixteenth of an inch, and in contrast to such tubes, pipes are regularly made by this process having an area of bore equal to ninety-five per cent. that of the outside measurement, and even this, it is claimed, may be readily exceeded if occasion should demand, as experiments which have been made clearly demonstrate.

"The pipes are made in the ordinary length, eighteen to twenty-three feet; they have, however, been turned out in lengths of forty-five feet and upwards, thus insuring a considerable decrease in the number of connecting pieces required.

"One use to which these tubes seem specially adapted, large numbers of them having already been placed on the market for that purpose, is for carbonic-acid reservoirs, their great strength and comparative lightness peculiarly fitting them for this purpose. They are made from one piece hammered together at both ends, thus entirely avoiding welded bottoms; tubes made in this manner have been tested up to 300 atmospheres (4,500 pounds) per square inch, and it is claimed as perfectly feasible to make them capable of withstanding a pressure of 16,000 pounds per square inch.

"Their use in the natural gas and petroleum industries will suggest itself, as well as for transmitting power long distances by means of compressed air, from what has already been said concerning their adoption in Europe for similar purposes.

"It has been found possible to roll a tube of a given length with the walls thicker at middle than at the ends, and then by making such tubes of rectangular or other desired section by re-rolling, to produce beams or girders of constant strength throughout their entire length, this being effected by making the billet from which the tube is to be rolled of less section in the middle than at the ends in the beginning of the process. It will be seen that by this means of producing beams, girders or other structural shapes, the maximum of strength may be obtained with a given amount of metal, in some structures, railway bridges and roof trusses for instance, an important consideration, and a use to which the product may be put. And the ordinary tube of cir-

cular section presents many advantages as structural material, by reason of the qualities of strength and lightness set forth above.

"The samples of these square and other profiles of what may be termed tube-rails prove the possibility of turning out Mannesmann-tubes in almost any desired form, which, if done, adds much to the available working material for the constructing engineer, and this feature of the manufacture and the product has been quite fully dwelt upon by various prominent engineers, among whom may be named Messrs. Frederick Siemens, J. G. Gordon, Profs. Angstrom, Wedding, Reuleaux and Von Hofer, who have, in papers read before engineering societies, described the merits and probable uses of this new form of structural material. Prof. Reuleaux has said of it in an address: 'It is undoubtedly true that we have in the Mannesmann process an epoch-making invention; it is certain to bring about a great change in rolling mills; it has, indeed, already a deep influence on rolling processes. The energy and untiring perseverance with which the inventors have worked out their plans and put them into actual use deserves our warmest appreciation.' The other engineers above named, all of them of unquestioned ability, have announced their confidence in and appreciation of the new invention in no less forcible terms than Prof. Reuleaux, just quoted.

"The tests to which some of the tubes exhibited had been submitted were most severe in their character, and fully showed the superiority of tubes of this method of manufacture over those made in the ordinary process of welding. Tests of compression and expansion from internal pressure have already been mentioned, but the distinctive characteristics of the Mannesmann tubes were, if need be, more fully shown by the torsional tests which had been applied. Specimens of these tubes were shown which had been bent, rolled and twisted in almost all conceivable shapes, but without destroying the tube or breaking or even cracking its walls, all of the tests being of a nature which would hopelessly have destroyed a welded tube of ordinary manufacture. [Some of the shapes into which these tubes have been bent and twisted were shown.]

"The use of Mannesmann tubes for all purposes where great strength, combined with lightness and absolute homogeneity of metal, as for car axles and similar uses, has been suggested. It has been found in the experiments which have been made that an inferior metal, one not perfectly homogeneous in its composition and quality, will not stand the test of being put through the Mannesmann rolls, that it is entirely impossible to form a tube out of imperfect material. This being the case, the very fact that a tube has been formed by this method is of itself at once a guaranty of the quality of the material used, and gives in the product a degree of safety in use never before attained.

"Regarding the physical structure of tubes made by this process, Dr. Wedding has found, in the examinations he has made with the microscope, that the metal shows a very distinct spiral structure. The tubes of cast steel have a number of extremely minute gas bubbles which wind through the metal, following closely the direction of the fibres. The presence of these

spaces does not appear materially to affect the strength of the pipe, since the tests show more than double the strength of similar wrought-iron tubes.

"At present there are four manufactories of these tubes, all of them being in Europe. Arrangements are being perfected by which the manufacture will be begun in this country, American capital to be enlisted for that purpose. The foreign works now in operation are located at Remscheid, Germany; one at Kotomau, Bohemia; a small works at Bous, Germany, and a large works at Landore, Wales, operated by the Mannesmann Tube Company."

BOOK NOTICES.

ELECTRO-CHEMICAL ANALYSIS. By Edgar F. Smith, Professor of Analytical Chemistry, University of Pennsylvania. (With twenty-five illustrations.) Philadelphia: P. Blakiston, Son & Co., 1012 Walnut Street. 1890.

The electrolytic process, as applied to the quantitative estimation of metals (principally of copper), until lately has been confined to the field of the assayer, and chemists as a body hitherto have practically ignored a method which, when intelligently employed, has been shown to be capable of comparing in accuracy with the most refined gravimetric and volumetric methods. It is, indeed, surprising that a field of work so inviting to the investigator, and which has yielded such splendid results in the hands of technical chemists, should have remained so long neglected. This reproach, happily, is in fair way to be removed, since the electrolytic method has of late attracted the thoughtful attention of a number of able investigators, through whose labors its value as an aid in analytical work has been fully demonstrated, and the scope of its applicability greatly widened, so that at present—thanks to the investigations of Classen, v. Reiss, Luckow, Smith, and others—it is receiving at the hands of instructors in chemistry the recognition to which it is entitled, of a place, side by side, with the older and standard gravimetric and volumetric methods.

Prof. Smith's little volume is a timely and useful addition to the list of text-books on this subject and will be particularly welcome to English and American students, for the reason that it brings the applications of the electrolytic method down to the present, showing incidentally how rapidly its scope has been extended, and supplements Classen's work on the subject, which hitherto has been the only one, in English, treating specially thereon.

Prof. Smith's volume is arranged with the special object of serving as a guide for the student, and the preliminary chapters, relating to the action of the electric current on acids and salts, the electric units, the sources of electric current, methods of regulating and measuring currents, are well adapted to his requirements.

The special part of the volume describes the methods employed for the quantitative determination of metals by electrolysis for the separation of metals from each other and their quantitative estimation by electrolysis, and for effecting oxidations by means of the electric current. A number of the processes therein described have originated with the author, who is well known as an able and indefatigable investigator in this domain. W.

CORRESPONDENCE.

To the Committee on Publications:

How to measure any angle without a protractor, or without trigonometrical tables has not to my knowledge been given anywhere.

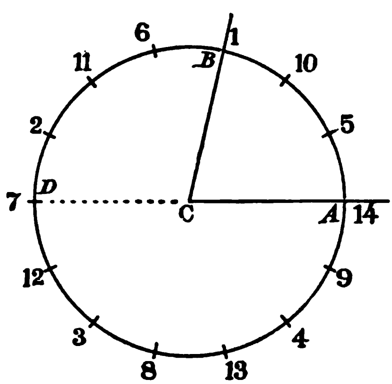
The following is my method, the accuracy of which is limited only by the skill of the operator.

Let it be required to measure the angle *A C B*.

Describe a circumference of radius *C A* and carry the chord *A B* around the circumference, several times if necessary, until one point of the dividers coincides with the point *A*.

In the case illustrated, this occurs after going around the circumference three times with fourteen steps of the dividers. The required measure is, therefore, $\frac{3}{14}$ of 360° or $77\frac{1}{7}$°.

The method, it is seen, consists simply in finding graphically a known arc which is an exact multiple of the arc to be measured.



In the case just considered the known arc is three times 360°; but, of course, it need not be a multiple of 360°, it may be one of 180° for instance. Producing the radius *A C* to *D* we find that seven steps of the dividers are exactly three times 180°, which gives as before for the required measure $77\frac{1}{7}$°.

It is, therefore, advisable in practice to increase the chances of obtaining a coincidence by dividing up the circumference into arcs of known value. The division into six equal parts is suggested as the simplest.

In cases where an exact coincidence is not obtainable, but one is assumed, the error made is divided by the number of steps taken by the dividers. This must happen whenever the angle to be measured is incommensurable.

JOSEPH BECKER.

WASHINGTON, November 1, 1890.

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Franklin Institute

[*Proceedings of the Stated Meeting, held Wednesday, November 19, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, November 19, 1890.

JOS. M. WILSON, president, in the Chair.

Present, 172 members and thirty-four visitors.

Additions to membership since last month, twenty-one.

The secretary presented letters from Prof. E. Mascart, of Paris, Col. Turrettini, of Geneva, and Prof. W. Cawthorne Unwin, of London, accepting election as honorary members of the Institute; from General A. W. Greely, Chief Signal Officer, in response to the official letter of the secretary transmitting the thanks of the Institute, expressing gratification on behalf of himself, Captain H. H. C. Dunwoody, and Sergeant T. F. Townsend, of the Signal Office, that the policy of the service has merited the approbation of the Institute, and the assurance of continued co-operation in the work of the State Weather Service; and from M. W. Grosseteste, Engineer of Mulhouse, presenting to the Institute a copy of a medal and a pamphlet prepared as a manifestation of honor to the late M. Gustav Adolph Hirn. In reference to the last communication, the gift was accepted with thanks, and the secretary was directed to acknowledge the courtesy of M. Grosseteste and his colleagues, and to convey to him and them a suitable expression of the high appreciation with which the members of the Franklin Institute esteem the scientific work of M. Hirn, which has added so much to our knowledge of the action of heat in the steam engine.

In the absence of Mr. F. Lynwood Garrison, the secretary presented a brief abstract of his paper announced for the evening, on the manufacture of tin-plate. (Referred for publication.)

Mr. Wm. B. LeVan read a paper, illustrated by numerous diagrams and specimens, on the proper method of making joints in steam-boilers. The paper was discussed by Messrs. Fullerton, Christie, Wiegand and the author. (Referred for publication.)

Mr. W. N. Jennings exhibited a series of photographic views on the screen, including several highly interesting pictures of lightning flashes, and commented briefly upon the same.

The secretary's report embraced a description of the process of the Mannesmann Brothers, for rolling seamless tubes of steel from the ingot, with the exhibition of a suite of remarkable specimens; an abstract of the report of the Committee on Science and the Arts on the product of the Eureka Tempered Copper Company, with the exhibition of a large variety of samples; and a description of two of the most recently devised machines of the matrix type, for casting type-bars for printing. These machines are designed to do away with the setting up of type by hand. The machines specially described were the improved linotype of Mr. Ottmar Mergenthaler, of New York, and the typograph devised by John R. Rogers, of Cleveland.

Adjourned. WM. H. WAHL, *Secretary.*

PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

For OCTOBER, 1890.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, October 31, 1890.

TEMPERATURE.

The mean temperature of 59 stations for October, 1890, was 50°·9, which is about 1°·0 below the normal, and 3°·7 above the corresponding month of 1889.

The mean of the daily maximum and minimum temperatures 58°·7 and 43°·2 give an average daily range of 15°·5, and a monthly mean of 50°·9.

Highest monthly mean, 56°·4 at Uniontown.

Lowest monthly mean, 44°·8 at Eagles Mere.

Highest temperature recorded during the month, 81°·0 on the 15th at Selins Grove.

Lowest temperature, 21°·0 on the 31st at Dyberry.

Greatest local monthly range, 55° at Wilkes-Barre.

Least local monthly range, 36° at Altoona.

Greatest daily range, 43° at Huntingdon on the 9th.

Least daily range, 1°·0 at Waynesburg on the 21st.

From January 1, 1890, to October 31, 1890, the excess in temperature at Philadelphia was 656°, at Erie 113° and at Pittsburgh 652°.

The coldest period of the month was on the 31st.

BAROMETER.

The mean pressure for the month, 29·92, is about ·15 below the normal. At the U. S. Signal Service Stations, the highest observed was 30·37 at Philadelphia on the 9th, and the lowest 29·28 at Erie on the 29th.

PRECIPITATION.

The average rainfall 5·87 inches for the month, is an excess of 2·50 inches.

The largest monthly totals in inches were Eagles Mere, 8·41; Uniontown, 7·41; Dyberry, 7·39; Lancaster, 7·34; Quakertown, 7·25; Columbus, 7·25; Somerset, 7·12.

The least were Mauch Chunk, 4·03; Altoona, 4·12; Wysox, 4·24; Wellsboro, 4·69; Meadville, 4·75; Philadelphia, 4·82; Wilkes-Barre, 4·85.

With the exception of the 9th, precipitation fell on every day on some sections of the State.

The following totals in snowfall were reported: Somerset, 5·25; Eagles Mere, 4·15; Grampian Hills, 3·50; Columbus, 3·00; Meadville, 2·25; Rimersburg, 1·75 and Greenville, 1·00 inches. The snowfalls occurred on the 27th, 28th, 29th, 30th and 31st.

WIND AND WEATHER.

The prevailing wind was from the West. The weather was nearly normal in temperature, and above in precipitation and humidity.

Average number: Rainy days, 15; clear days, 6; fair days, 8; cloudy days, 17.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Blue Knob, 1st, 18th; Coatesville, 29th; Kennett Square, 29th; Westtown, 29th; Meadville, 14th, 18th; Carlisle, 3d; Swarthmore, 29th; Philadelphia, 30th; Selins Grove, 2d; Lewisburg, 2d; Columbus, 6th.

Hail.—Blue Knob, 26th; Wysox, 30th; Coatesville, 29th; Wilkes-Barre, 14th; Greenville, 14th; Philadelphia, 30th; Eagles Mere, 19th; Dyberry, 23d.

Snow.—Charlesville, 30th, 31st; Blue Knob, 27th, 28th, 29th, 30th, 31st; Hollidaysburg, 30th; Le Roy, 27th, 28th; Johnstown, 27th, 28th, 29th, 30th, 31st; Emporium, 27th, 30th, 31st; Rimersburg, 29th, 31st; Meadville, 27th, 30th, 31st; Grampian Hills, 28th, 29th, 30th, 31st; Chambersburg, 29th; Waynesburg, 30th, 31st; Indiana, 14th, 29th, 30th; New Castle, 29th; Wilkes-Barre, 29th; Greenville, 26th, 27th, 29th, 30th, 31st; Girardville, 28th, 29th; Somerset, 28th, 29th, 30th; Eagles Mere, 27th, 28th, 29th, 30th; Columbus, 30th, 31st; Dyberry, 28th, 30th; Ligonier, 31st.

Frost.—Pittsburgh, 30th, 31st; Charlesville, 22d; Altoona, 20th, 27th, 30th, 31st; Blue Knob, 9th, 15th, 18th, 22d, 26th; Hollidaysburg, 31st; Tipton, 22d, 31st; Wysox, 30th, 31st; Le Roy, 22d, 31st; Quakertown, 9th, 21st, 22d, 30th, 31st; State College, 22d, 31st; Phœnixville, 18th, 22d, 31st; Coatesville, 18th, 22d, 26th, 28th, 30th, 31st; Westtown, 31st; Rimersburg, 21st, 22d, 28th; Grampian Hills, 15th, 18th; Lock Haven, 30th, 31st; Meadville, 15th, 18th, 22d; Carlisle, 22d; Harrisburg, 22d; Erie, 18th, 22d; Chambersburg, 29th; Huntingdon, 31st; Indiana, 8th, 26th; Lancaster, 22d, 31st; New Castle, 22d, 31st; Myerstown, 1st, 9th, 15th, 18th, 22d, 31st; Coopersburg, 9th, 22d, 30th; Wilkes-Barre, 10th, 13th, 18th, 31st; Nisbet, 18th, 20th, 21st; Greenville, 18th, 22d; Bethlehem, 21st, 30th, 31st; Philadelphia, 22d, 31st; Girardville, 8th, 9th, 10th, 13th, 15th, 16th, 19th, 20th, 21st, 22d, 23d, 24th, 25th, 26th, 27th, 28th, 29th, 30th, 31st; Selins Grove, 9th, 15th, 18th, 22d, 31st; Somerset, 22d; Eagles Mere, 8th, 9th, 18th, 21st, 22d; Wellsboro, 9th, 10th, 15th, 18th, 22d, 27th, 28th, 31st; Lewisburg, 1st, 22d; Columbus, 18th, 22d, 28th, 30th, 31st; Dyberry, 9th, 10th, 12th, 13th, 16th, 22d, 27th, 28th, 29th, 30th, 31st; Honesdale, 22d, 31st; Ligonier, 22d; South Eaton, 17th, 31st; York, 15th, 22d, 31st.

Sleet.—Blue Knob, 26th.

Service for October, 1890.

County	Precipitation: Total Snowfall During Month.	Precipitation: Number of Days Rainfall.	Number of Days: Clear.	Number of Days: Fair.	Number of Days: Cloudy.	Wind, Prevailing Direction: 7 A. M.	Wind, Prevailing Direction: 2 P. M.	Wind, Prevailing Direction: 9 P. M.	Observers.
Adams,[1]	...	...	...	...	...	...	...	...	Prof. E. S. Breidenbaugh.
Allegheny,[1]	...	20	1	8	22	W	W	W	Oscar D. Stewart, Sgt. Sig. Corps.
Bedford,	...	21	5	9	17	SW	SW	SW	Miss E. A. G. Apple
Blair,[2]	...	16	...	...	...	...	...	...	Dr. Charles B. Dudley.
Blair,	...	18	4	9	18	NW	NW	NW	A. H. Boyle.
Blair,	...	19	8	3	20	W	W	W	Prof. J. A. Stewart.
Blair,	...	15	9	8	14	W	W	W	Miss Cora J. Wilson.
Bradford,	...	18	7	2	22	SE	SE	SE	Charles Beecher.
Bradford,	...	18	6	5	20	SW	W	W	Geo. W. T. Warburton.
Bucks,	...	16	11	9	11	N	W	W	J. C. Hilsman.
Bucks,	...	17	8	6	17	NW	NW	NW	J. L. Heacock.
Cambria,[1]	...	23	4	9	18	S	S	S	E. C. Lorentz.
Cameron,	...	13	6	6	19	NW	NW	W	T. B. Lloyd.
Carbon,[1]	...	12	9	6	16	NW	NW	NW	John J. Boyd.
Centre,	...	21	2	10	19	W	W	W	Prof. Wm. Frear.
Centre,	...	17	...	...	...	SW	SW	SW	Geo. H. Dunkle.
Chester,	...	19	9	8	14	NW	NW	NW	Jesse C. Green, D.D.S.
Chester,	...	16	12	8	11	W	W	W	W. T. Gordon.
Chester,[1]	...	15	7	7	17	N	N	N	Benj. P. Kirk.
Chester,	...	16	7	5	19	NW	NW	NW	Knowles Croskey.
Chester,	...	12	8	9	14	W	W	E	Prof. Wm. F. Wickersham.
Clarion,	1·75	21	5	12	14	E	E	E	Rev. W. W. Deatrick, A.M.
Clarion,	...	6	7	7	14	SW	SW	SW	C. M. Thomas, B.S.
Clearfield,	3·50	18	2	10	19	W	W	W	Nathan Moore.
Clinton,	...	17	3	10	18	W	W	W	Prof. John A. Robb.
Columbia,	...	14	...	...	...	...	...	...	Robert M. Graham.
Crawford,	2·25	20	4	8	19	SW	W	W	J. & B. H. Metcalf.
Cumberland,	...	15	5	11	15	N	W	W	J. E. Pague.
Dauphin,[1]	...	15	8	6	17	W	W	W	Frank Ridgway, Sgt. Sig. Corps.
Delaware,	...	12	1	12	18	W	NW	NW	Prof. Susan J. Cunningham.
Erie,[1]	...	22	4	6	21	SW	SW	SW	Peter Wood, Sgt. Sig. Corps.
Fayette,	...	15	5	15	11	NW	NW	W	Wm. Hunt.
Franklin,[1]	...	10	8	8	15	...	...	...	Miss Mary A. Ricker.
Fulton,	...	14	8	10	13	N	N	NW	Thomas F. Sloan.
Greene,	...	...	...	...	...	...	...	...	Capt. W. C. Kimber.
Huntingdon,[1]	...	13	12	8	11	W	W	W	Prof. W. J. Swigart.
Huntingdon,	...	12	5	16	15	E	W	NW	J. E. Rooney.
Indiana,	...	17	4	9	18	NW	W	NW	Prof. S. C. Schmucker.
Lancaster,	...	15	3	10	18	NW	NW	NW	Lewis T. Lampe.
Lawrence,	...	10	5	8	18	NW	W	NW	Wm. T. Butz.
Lebanon,	...	14	12	2	17	W	W	W	Wm. H. Kline.
Lebanon,	...	...	...	...	...	...	...	...	Geo. W. Bowman, A.M., Ph.D
Lehigh,	...	16	8	6	17	SE	SE	NE	M. H. Boye.
Lehigh,[1]	...	...	...	...	...	...	...	...	John C. Wuchter.
Luzerne,	...	11	...	...	...	...	...	...	H. D. Miller, M.D.
Luzerne,[1]	...	15	10	1	20	NE	NE	NE	A. W. Betterly.
Lycoming,[1]	...	12	...	...	...	...	...	...	John S. Gibson, P. M.
Mercer,[1]	1·00	23	2	6	23	SE	...	N	Prof. S. H. Miller.
Mifflin,	...	...	...	...	...	...	...	...	Culbertson & Lantz.
Montgomery,	...	11	12	5	14	W	W	W	Charles Moore, D.D.S.
Northampton,	...	10	5	3	13	W	W	W	Lerch & Rice.
Philadelphia,	...	15	8	3	20	NW	NW	NW	Luther M. Dey, Sgt. Sig. Corps.
Schuylkill,	...	14	11	4	16	NW	NW	W	E. C. Wagner.
Snyder,	...	12	3	12	16	NW	NW	NW	J. M. Boyer,
Somerset,	5·25	16	1	9	21	NW	NW	NW	W. M. Schrock.
Sullivan,	4·15	16	5	6	20	SW	SW	SW	E. S. Chase.
Tioga,	...	17	3	6	22	NW	NW	NW	H. D. Deming.
Union,[1]	...	8	6	12	13	W	W	W	F. O. Whitman.
Warren,	3·00	...	...	9	20	SW	SW	SW	Wm. Loveland.
Washington,	...	...	...	...	...	...	...	...	A. L. Runion, M.D.
Wayne,	...	13	4	9	18	NW	NW	NW	Theodore Day.
Wayne,	...	14	...	...	...	...	...	...	John Torrey.
Westmoreland,	...	17	7	9	15	...	...	...	J. T. Ambrose.
Wyoming,[1]	...	12	4	8	19	NW	NW	NW	Benj. M. Hall.
York,[1]	...	17	9	4	18	NW	NW	NW	Mrs. L. H. Grenewald.

[1] Observa

T. F. Townsend, *Sergeant Signal Corps, Assistant.*

	Philadelphia.	Phillipsburg.	Phœnixville.	Pittsburgh.	Point Pleasant.	Pottstown.	Quakertown.	Reading.	Seisholtzville.	Selins Grove.	Smith's Corner.	Somerset.	South Eaton.	State College.	Swarthmore.	Tipton.	Uniontown.	Wellsboro.	West Chester.	Westtown.	Wilkes-Barre	Wysox.	York.
1	. .	. .	. .	·58	. .	. .	. .	. .	. .	. .	. .	·40	. .	·02	. .	. .	·42	. .	. .	. .	. .	. .	. .
2	·07	. .	·10	·61	·09	·12	·06	·10	·03	. .	·06	·75	. .	·03	·23	·70	1·26	. .	·32	1·22	. .	·36	·01
3	·76	·70	·75	·02	1·01	·80	2·09	·93	1·30	1·34	1·17	. .	1·10	·47	1·11	. .	. .	·10	·64	. .	·67	. .	1·50
4	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·03	. .	. .	. .	. .	. .	. .	·01	. .	. .
5	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·02	. .
6	·68	·40	·80	·27	. .	1·00	·50	·65	·45	·38	·53	·50	·24	·53	·97	·70	·45	·44	1·06	1·08	·31	·61	·80
7	·27	·35	·17	·02	·98	·32	·24	·23	·20	·22	·35	. .	·23	·05	. .	. .	. .	·05	·21	·42	·38	·08	·18
8	·01	·08	·02	. .	. .	. .	·13	. .	·04	. .	·02	. .	. .	. .	·02	. .	. .	. .	·08	. .	·30	. .	. .
9	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
10	. .	. .	. .	·14	. .	. .	. .	. .	. .	. .	. .	. .	. .	·02	. .	·12	·93	·04	. .	. .	. .	·07	. .
11	. .	·10	. .	·01	. .	. .	. .	. .	. .	. .	. .	. .	·01	. .	. .	. .	05	. .	. .	. .	. .	. .	·01
12	. .	·30	·01	·70	·03	. .	·09	·04	·06	·20	·05	·55	. .	·46	. .	·30	1·08	·02	·08	. .	·04	·01	·21
13	. .	·20	. .	1·21	. .	. .	. .	·01	. .	·17	. .	1·05	. .	·01	. .	·30	·24	. .	·02	·18	. .	·15	·07
14	·18	. .	·24	·18	·30	·20	·46	·32	·44	·03	·27	·40	·08	·23	·19	·20	·42	·08	·22	. .	·16	·15	·08
15	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·45	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
16	·17	. .	·26	·50	·29	·90	·50	·20	·35	·45	·29	. .	·05	·18	. .	·50	·45	·04	·42	·70	·68	·19	·75
17	·55	·60	·51	·02	·78	. .	·45	·66	. .	. .	·73	. .	·44	·28	·90	·05	. .	·28	·50	. .	. .	. .	·10
18	. .	. .	. .	·03	. .	. .	. .	. .	. .	. .	. .	·40	. .	. .	. .	·10	. .	. .	. .	. .	. .	·05	. .
19	·13	·30	·10	·19	. .	·38	·23	·29	·25	1·30	·43	·06	·94	·20	·03	. .	·41	·14	·11	·04	·69	·22	·35
20	·12	·20	·16	·03	·60	·15	·05	·01	. .	·15	·10	·15	·05	·44	·03	·24	·08	·26	·11	·09	·01	·14	·12
21	·13	. .	·02	. .	. .	. .	·04	. .	. .	. .	·06	. .	. .	. .	. .	. .	. .	. .	·03	. .	. .	. .	·01
22	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	·03	. .	. .
23	·82	·87	1·12	·31	·98	1·55	1·18	·95	1·34	1·00	1·07	1·25	1·01	1·46	·90	2·20	·79	2·68	1·54	. .	·55	1·64	1·28
24	·54	1·00	·68	. .	·59	·50	·90	·47	·75	1·71	·62	·20	·94	·55	1·20	. .	. .	·16	·47	1·80	·91	·06	1·02
25	·02	. .	·05	. .	. .	. .	·06	·02	·07	. .	·04	. .	. .	·03	·36	. .	. .	. .	·05	. .	. .	·02	·03
26	. .	. .	. .	. .	. .	. .	·04	. .	. .	. .	. .	. .	. .	. .	. .	·02	. .	·10	·01	. .	. .	·08	. .
27	. .	·08	. .	·08	. .	. .	. .	·01	. .	. .	. .	·20	. .	·02	. .	·03	·39	·02	. .	. .	. .	. .	. .
28	. .	·01	. .	·08	. .	. .	. .	. .	. .	. .	. .	·15	. .	·06	. .	. .	·07	. .	. .	. .	. .	. .	. .
29	·17	·05	·13	·43	·11	·18	·23	·42	·34	·02	·20	·45	·09	·16	·22	·25	·37	·16	·38	·22	·10	·38	·08
30	. .	·05	. .	·25	. .	. .	. .	. .	. .	. .	. .	·16	. .	·01	. .	·01	. .	·12	·03	. .	·01	·01	. .
31	. .	·02	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	4·82	5·31	5·12	5·66	5·76	6·10	7·25	5·31	5·60	6·97	5·99	7·12	5·18	5·24	6·16	5·72	7·41	4·69	6·28	5·75	4·85	4·24	6·6

T. F. T.

Aurora.—Le Roy, 17th; Coatesville, 17th; Grampian Hills, 17th, 18th; Wilkes-Barre, 3d; Nisbet, 17th; Eagles Mere, 5th, 17th.

Coronæ.—Myerstown, 1st; Dyberry, 18th, 22d, 25th.

Solar Halos.—Le Roy, 16th, 18th, 22d; Lock Haven, 22d; Philadelphia, 10th, 22d; Eagles Mere, 9th, 16th, 22d; Wellsboro, 14th, 23d, 30th; Dyberry, 16th.

Lunar Halos.—Le Roy, 22d; Phœnixville, 22d; Rimersburg, 20th, 25th; Meadville, 1st, 21st; Coopersburg, 22d; Eagles Mere, 22d; Dyberry, 22d.

Meteors.—Le Roy, 17th.

WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for October, 1890:

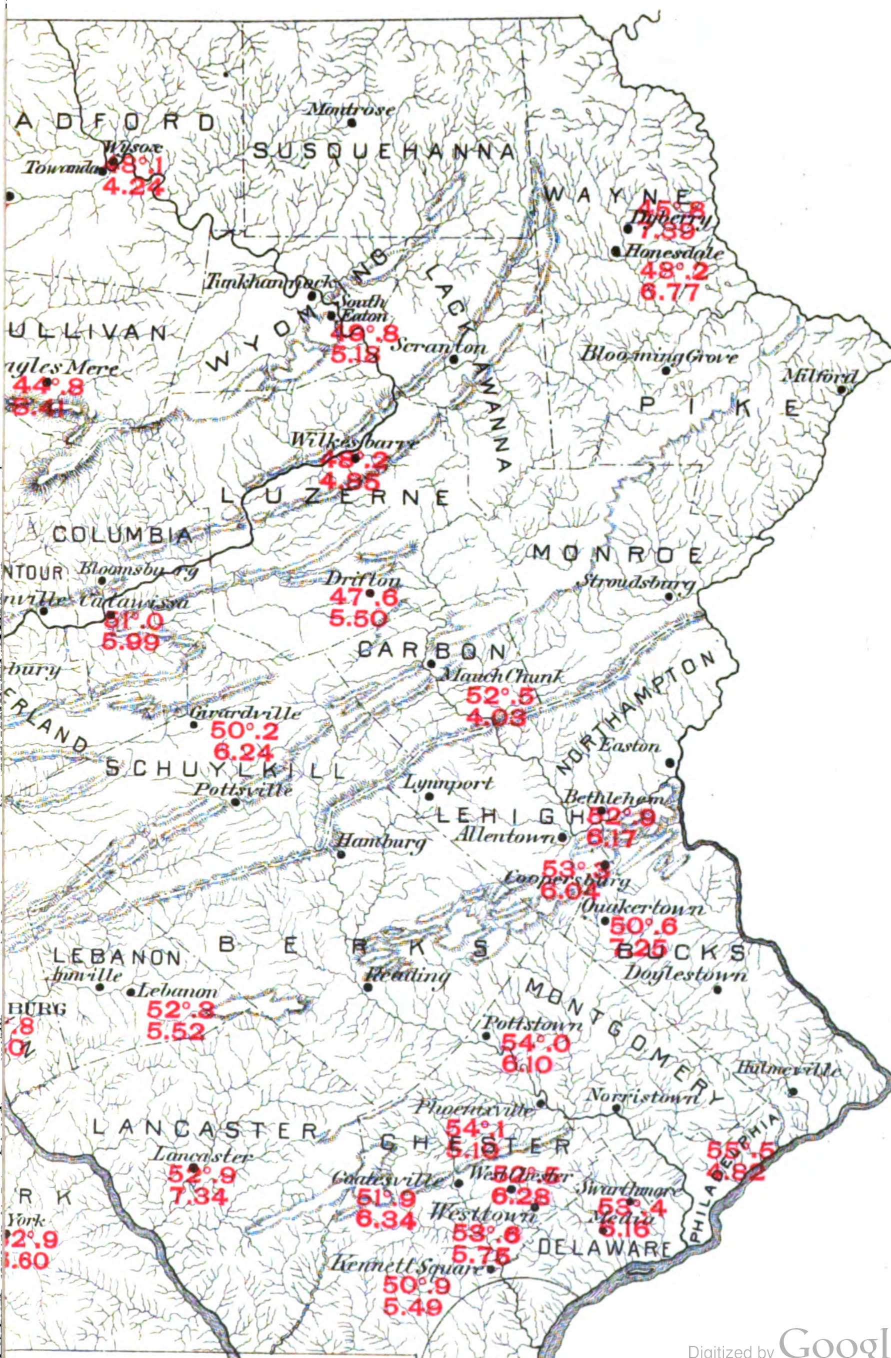
Weather, 78 per cent.
Temperature, 87 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
C. W. Burkhart,	Shoemakersville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
Capt. A. Goldsmith,	Quakertown.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
New Era,	Lancaster.
D. G. Hurley,	Altoona.
J. E. Forsythe,	Butler.
Steward M. Dreher,	Stroudsburg.
State Normal School,	Millersville.

Displayman.	*Station*
E. C. Wagner,	Girardville.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. M. Wildman,	Langhorne.
G. W. Klee,	Chambersburg.
A. Simon's Sons,	Lock Haven.
Raftsman's Journal,	Clearfield.
R. C. Schmidt & Co.,	Belle Vernon.
Chas. B. Lutz,	Bloomsburg.
E. C. Lorentz,	Johnstown.
W. M. James,	Ashland.
Miller & Allison,	Punxsutawney.
Dr. A. L. Runion,	Canonsburg.
E. J. Sellers,	Kutztown.
C. A. Hinsdell,	Scranton.
H. M. Kaisinger,	Hartsville.
Foulk & Co.,	Milford.
William Lawton,	Wilmington, Del.
Wister Heberton & Co.,	Germantown.
Charles M. Mullen,	Bedford.
E. W. Merrill,	North East.
A. Simon's Sons,	Lock Haven.
Frank Ridgway,	Harrisburg.
G. W. Yost,	Collegeville.
A. C. Tryon,	Spartansburg.
A. H. Gerbench,	Annville.
Knowles Croskey,	Phoenixville.
Powell Bros.,	Shadeland.
Lincoln E. Rowley,	Athens.

OBER, 1890.


SUSQUEHANNA
Montrose
Wysox
Towanda
48°.1
4.24
WAYNE
Dyberry
45°.8
7.39
Honesdale
48°.2
6.77
Tunkhannock
WYOMING
LACKAWANNA
South Eaton
49°.8
5.18
Scranton
ULLIVAN
Eagles Mere
44°.8
8.41
Blooming Grove
Milford
PIKE
Wilkesbarre
48°.2
4.85
LUZERNE
COLUMBIA
MONROE
Bloomsburg
Catawissa
51°.0
5.99
Drifton
47°.6
5.50
Stroudsburg
CARBON
Mauch Chunk
52°.5
4.03
NORTHAMPTON
Girardville
50°.2
6.24
Easton
SCHUYLKILL
Pottsville
Lynnport
Bethlehem
52°.9
6.17
LEHIGH
Allentown
Hamburg
Coopersburg
53°.3
6.04
Quakertown
50°.6
7.25
LEBANON
BERKS
BUCKS
Annville
Lebanon
52°.8
5.52
Reading
Doylestown
MONTGOMERY
Pottstown
54°.0
6.10
Hulmeville
Norristown
Phoenixville
54°.1
5.15
LANCASTER
CHESTER
PHILADELPHIA
55°.5
4.82
Lancaster
52°.9
7.34
Coatesville
51°.9
6.34
West Chester
52°.5
6.28
Swarthmore
Media
53°.4
6.16
Westtown
53°.6
5.75
DELAWARE
York
Kennett Square
50°.9
5.49